INSTRUCTION MANUAL
MODELS 119/121
FUNCTION GENERATORS

EXACT ELECTRONICS, INC.
All rights reserved
PRINTED IN U.S.A.
REV 1-81

® Box 347 Tillamook OR 97141
Telephone 503-842-8441
TWX 510-590-0918
EXACT electronics, inc.

IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper setup.
2. Check fuse and power supply voltages.
3. Call your Exact representative or factory. Instruments returned to the factory will be accepted only if they are sent freight prepaid, unless Exact or factory representative has authorized otherwise.

CLAIM FOR DAMAGED SHIPMENT

The instrument should be inspected as soon as received. If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage and a copy sent to Exact. After receiving this report, Exact will advise you of the dispostion of the instrument and arrange for its repair or replacement.

WARRANTY

Exact warrants its instruments to be free from defects in material and workmanship under normal use for a period of twelve months from the original date of shipment. Exact's obligation is limited to repair or replacement.

All repairs and replacements made under this warranty are f.o.b. Exact's factory or designated service depot unless otherwise authorized by Exact. This warranty is made on condition that prompt notice of defect is given to Exact, in writing, within the warranty period and that Exact shall have the sole right to determine whether in fact a defect exists.

This warranty does not apply to any instrument which has been repaired or altered by other than Exact's own service representative so as, in Exact's judgment, to adversely affect it, nor which has been subject to misuse, negligence or accident or which has been operated contrary to sound practice or operating instructions.

CONTENTS

SECTION 1	GENERAL DESCRIPTION AND SPECIFICATIONS
SECTION 2	INSTALLATION AND OPERAYION
SECTION 3	SPECIFICATION VERIFICATION
SECTION 4	THEORY OF OPERATION
SECTION 5	MAINTENANCE, CALIBRATION, AND TROUBLESHOOTING
SECTION 6	SCHEMATICS
SECTION 7	PARTS LIST
SECTION 8	ADDENDA

SECTION 1

GENERAL DESCRIPTION AND SPECIFICATIONS

INTRODUCTION

The Exact Models 119 and 121 Sweep-Function Generators provide square, triangle, sine, ramp, and pulse waveforms over a frequency range of 0.2Hz to 2MHz, (0.02Hz to 200kHz with obtion B) plus a VCF (voltage-controlled frequency) input, variable DC Offset and TTL Pulse output.

The MODEL 121 has an internal sweep generator that provides a linear sweep from 1mS to 10Sec for sweeping the main generator over three decades (1000:1). A ramp sync output and auxiliary ramp output are also provided. The MODEL 119M includes an AM input for modulating or controlling the amplitude.

MECHANICAL DESCRIPTION

Case/Top and Bottom Covers

The instrument case is made of lightweight plastic. The top and bottom covers are made of ABS plastic for extreme ruggedness and flexibility. Front and rear bezels are made of Lexan 500 for maximum strength and rigidity. The instrument requires no ventilation holes because of its low power consumption.

Front Panel

The main output and all controls are on the front panel. They are: the pushbutton POWER switch, power ON indicator, seven frequency RANGE pushbutton switches, three pushbutton FUNCTION switches, RAMP/PULSE INVERT pushbutton switch, frequency MULTIPLIER (variable, VAR RAMP/PULSE potentiometer, DC OFFSET control, and output AMPLITUDE control, OUTPUT HI, and OUTPUT LO. The MODEL 121 includes a sweep WIDTH control, sweep RATE control, and two SWEEP RANGE pushbutton switches. The MODEL 119M includes an AM switch, MODULATION control, and a CARRIER CONTROL.

Rear Panel

On the rear panel are the power cord, fuse, VCF (Voltage-controlled-frequency) input, TTL pulse output, ramp sync output (121), aux ramp output (121), and AM input (119M).

Printed Circuit Boards

MAIN GENERATOR: All circuitry, the power supply, and power transformer are on the main P.C. board. All controls, the POWER switch, and ON indicator are also on the main P.C. board.

SWEEP GENERATOR: The internal sweep generator in the MODEL 121 is on a separate P.C. board mounted to the front bezel. All sweep controls are mounted on the sweep board.

AMPLITUDE MODULATOR: The amplitude modulator in the MODEL 119M is on a separate P.C. board mounted to the front bezel. All AM controls are mounted on this board.

LOCKOUT: The lockout circuitry in the MODEL 119L is on a separate P.C. board mounted to the front bezel. All TRIG/GATE controls are mounted on this board.

SPECIFICATIONS

Specifications are listed below in Table 1-1. Test procedures for verification of specifications are given in Section 3.

Main Generator:	
Frequency Range:	0.2Hz to 2MHz (7 ranges) Option B: 0.02Hz to 200kHz
Frequency Accuracy	± 5% of full scale
VCF (Voltage Controlled Frequency)	Approx. 0 to 10 volt input for 1000:1 (3 decades) frequency ratio. Input impedance - Approx. 10K Ohms

Table 1-1 Specifications

WAVEFORMS

Sine, triangle, square, pulse, and ramp

MAIN OUTPUT

*50 Ohms
Amplitude - > 20V P-P open circuit
- > 10V P-P into *50 Ohms
**Attenuation - 30dB continuously variable plus 30dB for the *LO output

DC OFFSET (variable)

+10 to -10 volts open circuit
+5 to -5 volts into *50 Ohms
NOTE: The output signal will be automatically clipped for protection if the DC offset plus the signal exceeds the maximum peak voltage.

SINE DISTORTION

< 1% 0.2Hz to 200kHz, typically < 0.5% -30dB 200kHz to 2MHz (all harmonics) measured at full output, between 0.2 and 2.0 on the dial.

SINE FREQUENCY RESPONSE

< 0.1dB 0.1Hz to 200kHz
< 0.5dB 200kHz to 2MHz

SQUAREWAVE

Rise Time - < 100nSec Abberations < 5% max P-P amplitude

* Option K is 600 Ohms and has no LO output.
** Option A is 30dB continuously variable plus a 0-20-40dB switch

SPECIFICATIONS (continued)

PULSE OUTPUT

TTL Compatible, Amplitude Fixed > +3V open circuit. < 25nSec rise time.
Will sink 20 TTL loads

SWEEP GENERATOR (121)

FREQUENCY RANGE

1mS to 10Sec (2 ranges)

FREQUENCY ACCURACY

± 10% (Cal Position) 100:1 Variable

SWEEP WIDTH

Continuously variable to 1000:1 (3 decades)

RAMP RESET TIME

Approximately 15% of range.

AM (119M)

Approximately 100K input impedance.
DC coupled.
Approximately 5V P-P for 100% AM.
In the AM mode, other specifications are not valid.

POWER REQUIREMENTS

-115 VAC ± 10% or 230 VAC ± 10% 50/60Hz
Approximately 5 watts (can be wired for other voltages).

PHYSICAL CHARACTERISTICS

7 3/8" wide x 2 7/8" high x 8 1/2" deep.
Weight - Approximately 2 lbs.

NOTE: (Unless otherwise stated). Specifications apply 10% to maximum output voltage, terminated into the rated load impedance, between 0.2 and 2 Multiplier settings.
Specifications are valid at 25° C ± 5°C after 1 hour warmup time.
Specifications are NOT valid in AM mode.

SECTION 2

INSTALLATION AND OPERATION

UNPACKING AND INSPECTION

The MODEL 119 and 121 Function Generators are packaged to absorb any reasonable shock encountered during shipping.

Carefully remove the instrument from the shipping container and inspect for shipping damage. If damage is found, SAVE THE SHIPPING CONTAINER and notify the carrier immediately.

AC POWER REQUIREMENTS

These Models operate on line voltages of 100, 117, 200, 220, and 240 VAC ± 10% 50/60Hz.
Power requirements are typically 5 watts.

Unless specifically ordered otherwise, the instrument is wired for 117 VAC.

To operate the instrument at a different line voltage, it is necessary to change one or two jumpers on the P.C. board. Perform the following steps:

A. With the instrument unplugged, remove the top and bottom covers as described under dissassembly steps, Section 5.

B. From Figure 6-3 select the jumper or jumpers corresponding to the desired line voltage of operation.

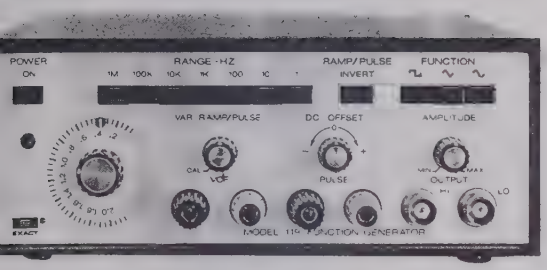
C. Remove the jumpers previously installed in the P.C. board (Fig. 6-2).

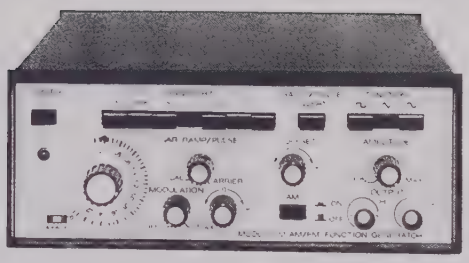
D. Install the jumpers corresponding to the desired line voltage.*

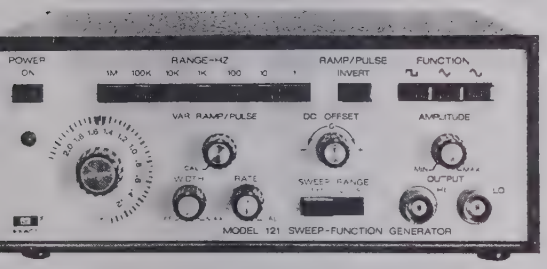
E. From Figure 6-3 select the proper terminal number for the white wire from the power cord (No.5 or No. 6).

F. If the white wire needs to be moved, unsolder it and resolder to the appropriate eyelet indicated on Figure 6-3.

WARNING: *BE SURE TO INSULATE JUMPERS TO PREVENT SHOCK HAZARD.







FRONT PANEL
CONTROLS AND INDICATORS
FIG 2-1

CONTROLS

POWER Switch

The power switch applies power.

Power ON Indicator

A light emitting diode (LED) indicates when power is applied. Because the LED is a solid-state device, its life expectancy, like most other solid-state devices, is indefinite.

RANGE Switch

Seven fixed decades of frequency are provided by the RANGE pushbutton switch. The seven switches are interlocking. Depressing one pushbutton will release all others.

FUNCTION Switch

Three interlocking pushbutton switches select the desired output waveform. Depressing one switch releases the switch previously depressed. Square, triangle, and sine waveforms are provided, satisfying most applications. By only partially depressing a switch, all three switches can be disengaged simultaneously. This allows using the generator output as a DC source controlled by the DC OFFSET pot.

MULTIPLIER

The MULTIPLIER is a variable potentiometer allowing frequency settings between fixed ranges. Although the dial skirt is calibrated from 0.2 to 2.0, the dynamic range of the MULTIPLIER dial is 1000:1 (three decades). For example, this allows frequency settings between 200kHz and 200Hz without changing ranges. NOTE: This is necessary when sweeping up in frequency over a three decade range 1000:1. For further information concerning sweeping, refer to Section 4, (Summing Amplifier).

VARIABLE RAMP/PULSE

Time symmetry of the OUTPUT waveforms, including the TTL PULSE output, is controlled by the VAR RAMP/PULSE potentiometer.

When this control is set to the CAL position, the time symmetry of the output waveforms is 50/50 (approximately 100% symmetrical).

This control allows the time period of one-half the waveform to be changed while the other half remains fixed as determined by RANGE and MULTIPLIER settings. This unique feature provides ramp waveforms, variable pulse width and variable duty cycle pulses, and skewed sinewaves.

RAMP/PULSE INVERT

A pushbutton switch inverts the time symmetry set by the VARIABLE RAMP/PULSE control.

Table 2-1 illustrates the effect of the RAMP/PULSE INVERT switch and VAR RAMP/PULSE control.

Ramp/Pulse Invert Switch	Variable Ramp Pulse Control	MAIN OUTPUT Square	Triangle	Sine	Pulse Output
Out	Cal				
In	Cal				
In	Max CW				
Out	Max CW				

Table 2-1 Variable Ramp/Pulse Control

NOTE: The time symmetry illustrated above is for reference only. Any desired time-symmetry ratio may be set within the limits described in Section 4, (Var Ramp/Pulse).

DC OFFSET

A DC OFFSET control allows setting the DC level of the OUTPUT waveforms as desired. The OFF position disconnects the DC OFFSET control.
NOTE: If the amount of offset plus the waveform amplitude exceeds the maximum P-P amplitude, automatic clipping will occur. By disengaging all three waveforms, the DC OFFSET acts as a variable power supply control for the generator output.

AMPLITUDE

The AMPLITUDE control provides 30dB attenuation of the output waveform.

HI OUTPUT

Square, triangle, sine, ramp, and pulse waveforms are provided at up to 20V P-P amplitude (open circuit) at the HI OUTPUT.

LO OUTPUT

The LO OUTPUT is 30dB down from the HI OUTPUT. In combination with the 30dB provided by the amplitude control this provides a maximum attenuation of 60dB. Option A replaces the 2 outputs with one output and adds a 0-20-40dB attenuator switch. Option K changes the output impedance to 600 Ohms and replaces the 2 BNC outputs with a single output pair of 5-way binding posts.

WIDTH (Model 121 only)

The width control sets the sweep width as desired up to a three decade (1000:1) range.

RATE (Model 121 only)

This control adjusts the sweep rate over a two decade (100:1) range.

SWEEP RANGE (Model 121 only)

Two pushbutton-selected ranges allow 1mS to 10S Sweep rates.

NOTE: The VCF input and PULSE outputs on the Model 119 are front-panel binding posts. On the Model 119M and 121 these are rear-panel banana jacks.

VCF INPUT

A VCF (voltage-controlled-frequency) input is provided for externally sweeping or controlling the frequency. Approximately +10V applied at the VCF input will sweep the generator frequency down three decades (1000:1). The generator may also be swept up in frequency by applying a negative voltage at the VCF input. This input can also be used to fine-tune the frequency or to frequency modulate.

PULSE OUTPUT

The PULSE OUTPUT is suitable for driving TTL logic. The rise- and fall- time is typically 10nS. The pulse width and repetition rate may be set as desired by using the RANGE, MULTIPLIER, and VARIABLE RAMP/PULSE controls. The symmetry of the PULSE output is controlled the same way as the output waveforms described in Table 2-1.

RAMP OUTPUT (Model 121 only)

The Ramp Output signal is a negative sweep waveform of approximately -2.5V peak. The Ramp Time is set by the sweep RATE and sweep RANGE controls.

RAMP SYNC OUTPUT (Model 121 only)

The RAMP SYNC output is a positive pulse of approximately +5V coincident with the reset time of the sweep waveform.

AM (Model 119M only)

A pushbutton switches the Modulator in or out. When the AM is on, specifications for distortion, symmetry, and output amplitude are not valid.

CARRIER (Model 119M only)

The CARRIER control allows the carrier level to be adjusted and its phase inverted. This provides full four quadrant and double-sideband suppressed-carrier capabilities. The AM switch must be engaged.

MODULATION (Model 119M only)

The MODULATION control adjusts the AM input sensitivity. The AM switch must be engaged.

AM INPUT (Model 119M only)

The AM INPUT allows remote amplitude control and Amplitude Modulation of the carrier. Approximately 5V of either polarity will provide full output during remote amplitude control; approximately 10V P-P is required for full double-sideband suppressed-carrier modulation; and approximately 5V P-P is required for 100% AM. The input impedance is 100K Ohms.

RUN (Model 119L only)

Allows generator to free run continuously.

TRIG (Model 119L only)

In this mode, one complete cycle is produced each time the TRIG IN signal exceeds the trigger threshold or each time the MAN pushbutton is depressed.

GATE (Model 119L only)

In this mode, the generator will free run as long as the TRIG IN signal is above the trigger threshold or as long as the MAN pushbutton is depressed. An integer number of cycles is always produced.

START LEVEL (Model 119L only)

Adjusts the start phase of the waveforms over a $\pm 90^{\circ}$ range when in GATE or TRIG mode. Allows user to produce haversine and $\sin^2$ waveforms.

TRIG IN (Model 119L only)

Rear panel BNC connector accepts signals for externally triggering or gating the generator when in GATE or TRIG mode.

FIRST TIME OPERATION

NOTE: Before applying power be sure the proper line voltage is available. Plug the power cord into the proper source of 115VAC 50-60Hz. All instruments are wired for 115VAC unless otherwise ordered from Exact. The proper procedure for rewiring is described in Section 2 (AC Power Requirements). Set the controls as follows:

RANGE-HZ	10K
MULTIPLIER	2.0
FUNCTION	TRIANGLE
VAR RAMP/PULSE	CAL
AMPLITUDE	MAX
OFFSET	OFF
WIDTH	OFF (Model 121 only)
ATTENUATOR (Option A)	0dB
AM	OFF
CARRIER	0 (Model 119M only)
MODULATION	OFF (CCW)

MAIN OUTPUT

Connect an oscilloscope to the HI OUTPUT. Observe a 20V P-P 20kHz triangle waveform.

FUNCTION SWITCH

Select and observe a 20V P-P squarewave and sinewave.

AMPLITUDE CONTROL

Rotate the AMPLITUDE vernier from maximum to minimum and observe at least 30dB of attenuation.

ATTENUATOR SWITCH (Option A)

Reset the AMPLITUDE control to maximum. Change the ATTENUATOR to 20dB, observe a 10% voltage reduction, change it to 40dB and observe an additional 10% voltage reduction (100% total). Reset ATTENUATOR to 0dB.

LO OUTPUT (Except with A or K options)

Connect the oscilloscope to the LO OUTPUT and observe the signal level 30dB lower than the HI OUTPUT level.

DC OFFSET

Reconnect the oscilloscope to the HI OUTPUT and select the triangle waveform. Rotate the DC OFFSET control and observe the peaks will "clip" when the DC OFFSET plus the peak amplitude exceeds ± 10V. Reduce the output amplitude and observe that the DC OFFSET may be increased by the same amount the peak amplitude has been decreased. Return the DC OFFSET to OFF and the AMPLITUDE to maximum.

VAR RAMP/PULSE CONTROL

While observing the triangle waveform on the oscilloscope, rotate the VAR RAMP/PULSE control CW from the CAL position. Observe that one slope of the triangle remains constant while the other slope is variable over a 20:1 range (typical), producing a ramp waveform.

RAMP/PULSE INVERT SWITCH

Depress the RAMP/PULSE INVERT pushbutton. The positive and negative slopes of the ramp waveform reverse (invert).

By selecting the squarewave and repeating the same procedure, the Model 119 and 121 Function Generators become very versatile pulse generators. The pulse width may be determined by the following formula:

PULSE WIDTH = the reciprocal of 2 X freq. setting.

In other words, the pulse width equals one-half the time period of the frequency set by the RANGE and MULTIPLIER controls.

The time symmetry of the sinewave may be set in the same manner, providing additional versatility.

NOTE: The VAR RAMP/PULSE control and RAMP/PULSE INVERT switch provide the same flexibility for the PULSE output.

PULSE OUTPUT

Connect the oscilloscope to the PULSE output. By adjusting the generator frequency, the VAR RAMP/PULSE control and the RAMP/PULSE INVERT switch, the highspeed TTL pulse may be used as a very versatile pulse generator. With

PULSE OUTPUT (continued)

the RAMP/PULSE switch in the NORM position (out), the pulse width "on time" is determined by the RANGE and MULTIPLIER settings and the repetition rate "off time" is set by the VAR RAMP/PULSE control.

NOTE: When the RAMP/PULSE INVERT switch is set to INVERT, the pulse "off time" is determined by the RANGE and MULTIPLIER setting and the pulse "on time" is set with the VAR RAMP/PULSE control.

SWEEP RANGE (Model 121 only)

Connect the oscilloscope to the auxiliary RAMP OUTPUT on the rear panel. Select the 1mS SWEEP RANGE. Set the rate control to the CAL position (MAX CW). Observe a negative sweep waveform with approximately 1mS ramp time.

RATE (Model 121 only)

Rotate the rate control and observe the ramp duration is variable from 1mS to 100mS. Select the 100mS sweep RANGE and observe the ramp duration is adjustable from 100mS to 10Sec.

WIDTH (Model 121 only)

Connect the oscilloscope to the MAIN OUTPUT and observe a 20kHz triangle waveform. Select the 100mS SWEEP RANGE and set the sweep rate to mid-position (approx. 1Sec). Set the MULTIPLIER to 0.2 and RANGE to 10kHz (2kHz).

Rotate the sweep WIDTH control CW from the OFF position. By setting the sweep width properly, the main generator will sweep from 2kHz to 20kHz at approximately a 1Hz rate. (As set by the RATE and SWEEP RANGE setting).

By setting the MULTIPLIER to <0.2 and increasing the sweep WIDTH control setting, the generator will sweep a three decade (1000:1) range.

RAMP OUTPUT (Rear Panel Model 121 only)

Connect the oscilloscope to the ramp output on the rear panel and observe a negative ramp (sweep waveform).

RAMP SYNC OUTPUT (Rear Panel Model 121 only)

Connect the oscilloscope to the Ramp Sync output on the rear panel and observe a positive pulse coincident with the ramp fall time.

AM (Model 119M only)

Connect the oscilloscope to the HI OUTPUT and set the generator for a 200kHz sinewave. Observe a 20V P-P 200kHz sinewave.

Now engage the modulator by depressing the AM pushbutton. Observe a 200kHz sinewave at a reduced amplitude. The amount of reduction will depend on the CARRIER setting.

CARRIER (Model 119M only)

Externally trigger the oscilloscope from the 119M PULSE OUTPUT (rear panel). Vary the CARRIER control. Observe that the waveform is at minimum amplitude when CARRIER is centered ('0') and at maximum amplitude when CARRIER is fully CW or fully CCW. Also observe phase reversal as the CARRIER control passes through '0'.

MODULATION (Model 119M only)

Adjust CARRIER for 5V P-P output. Apply a 5V P-P 400Hz triangle or sinewave to the 119M rear-panel AM input. Rotate MODULATION clockwise and observe a 200kHz carrier modulated by a 400Hz tone. Note that the MODULATION control sets the modulation percentage. Rotate CARRIER to '0' and observe a double-sideband suppressed-carrier signal.

REMOTE CONTROL OF AMPLITUDE (Model 119M only)

1. With the AM pushbutton disengaged, set up the generator for the frequency waveforms, and maximum amplitude desired.

2. Engage the AM pushbutton. With the MODULATION control off (CCW), adjust the carrier control for minimum output.

3. Apply your maximum external control voltage to the rear panel AM input, and slowly increase the MODULATION control setting until the desired maximum output signal is obtained. NOTE: When the MODULATION control is set to MAX (CW), approximately 5V of either polarity will produce the maximum output signal.

4. By using a Digital-to-Analog Converter (DAC) between a computer port and the 119M input, you can program the amplitude with the computer. (A second DAC could be used with the VCF input for frequency control).

Model 119L only

Connect the oscilloscope to the HI OUTPUT. Set the 119L function generator controls as follows:

RANGE-HZ	1K
MULTIPLIER	2.0
FUNCTION	TRIANGLE
VAR RAMP/PULSE	CAL
AMPLITUDE	MAX
OFFSET	OFF
RUN	OUT
GATE	OUT
START LEVEL	CENTERED

Model 119L only (continued)

Depress the MAN pushbutton. Observe a single triangle waveform being generated each time the button is pushed. Connect an external signal source to the TRIG IN BNC on the rear panel. The signal source should have a positive excursion of at least 0.5V and a frequency of about 500Hz. Observe a single triangle waveform occurring about every 2mS. Rotate the START LEVEL control and observe the starting DC voltage level changing.

Depress GATE. Adjust the DC offset of the signal source (or amplitude if it is a positive going ramp generator) and observe the number of cycles generated will change from none to a free run condition. Disconnect the external signal source. Depress MAN and observe the generator will free run as long as the MAN pushbutton is held IN.

SECTION 3

SPECIFICATION VERIFICATION

GENERAL

This procedure will ensure that the instrument is operating properly and within its specifications. If any reading is not within tolerance, refer to the Calibration Procedure.

If the instrument fails to operate properly, refer to the Troubleshooting Procedure.

PREPARATION

Allow at least 30 minutes warm-up time before checking specifications or attempting to re-calibrate.

EQUIPMENT

Table 3-1 is a list of test equipment necessary for complete specification verification or calibration.

EQUIPMENT	REQUIRED SPECS
Oscilloscope	Bandwidth > 20MHz Rise Time < 10nS Vert. Accuracy ± 3% Horiz. Accuracy ± 5%
Frequency Counter	Freq. Accuracy ± .1% Freq. Response > 10MHz
Voltage Source	> 10V Output (Variable Well Regulated
Distortion Analyzer	Freq. Response > 100kHz Residual Distortion < .1%

Table 3-1 Required Test and Calibration Equipment

PROCEDURE

Connect the test equipment as shown in the table for each accuracy check. Set all controls as indicated in each table and perform the measurements as called out in each case.

PROCEDURE (continued)

Set controls as indicated below for all accuracy checks unless indicated otherwise in the table.

POWER	ON	
RANGE	REFER TO TABLES	
MULTIPLIER	REFER TO TABLES	
RAMP/PULSE	NORM (OUT)	
FUNCTION	∿	
VAR RAMP/PULSE	CAL (MAX CCW)	
DC OFFSET	OFF	
AMPLITUDE	MAX (MAX CW)	
ATTENUATOR (Option A)	0dB	
WIDTH	OFF	
RATE	CAL	MODEL 121 ONLY
SWEEP RANGE	1mS	
AM	OFF	
CARRIER	'0'	MODEL 119M ONLY
MODULATION	OFF	
RUN	IN	MODEL 119L ONLY
GATE	OUT	
START LEVEL	CENTERED	MODEL 119L ONLY

RANGE MULT		FREQUENCY SETTING	MEASURED FREQUENCY MAX MIN	TIME PERIOD SHOULD BE	MEASURED TIME PE MAX MIN
*1M		2.0000MHz	2.1000 to 1.9000MHz	0.5000μS	0.52632 to 0.47619
100K		200.00kHz	210.00 to 190.00kHz	5.000μS	5.2632 to 4.7619μS
10K		20.000kHz	21.000 to 19.000kHz	50.000μS	52.632 to 47.619μS
1K	2.0	2.0000kHz	2.1000 to 1.9000kHz	0.5000mS	0.52632 to 0.47619
100		200.000Hz	210.00 to 190.00Hz	5.0000mS	5.2632 to 4.7619mS
10		20.000Hz	21.000 to 19.000Hz	50.000mS	52.632 to 47.619mS
1		2.0000Hz	2.1000 to 1.9000Hz	0.5000Sec	.52632 to .47619Se
*1M		200.00kHz	300.00 to 100.00kHz	5.0000μS	3.3333 to 10.000μS
100K		20.000kHz	30.000 to 10.000kHz	50.000μS	33.333 to 100.00μS
10K		2.0000kHz	3.0000 to 1.0000kHz	0.5000mS	0.33333 to 1.0000m
1K	0.20	200.00Hz	300.00 to 100.00Hz	5.0000mS	3.3333 to 10.000mS
100		20.000Hz	30.000 to 10.000Hz	50.000mS	33.333 to 100.00mS
10		2.0000Hz	3.0000 to 1.0000Hz	0.5000S	0.33333 to 1.0000m
1		0.20000Hz	0.30000 to 0.10000Hz	5.0000S	3.3333 to 10.000S
*1M		1000.00kHz	1100.0 to 900.00kHz	1.0000μS	1.1111 to 0.90909μ
100K		100.000kHz	110.00 to 90.000kHz	10.000μS	11.111 to 9.0909μS
10K		10.0000kHz	11.000 to 9.0000kHz	100.00μS	111.11 to 90.909μS
1K	1.0	1000.00Hz	1100.00 to 900.00Hz	1.0000mS	1.1111 to 0.90909m
100		100.000Hz	110.00 to 90.000Hz	10.000mS	11.111 to 9.0909mS
10		10.0000Hz	11.000 to 9.0000Hz	100.00mS	111.11 to 90.909mS
1		1.00000Hz	1.1000 to 0.90000Hz	1.0000S	1.1111 to 0.90909S

*There is no 1M range with option B.

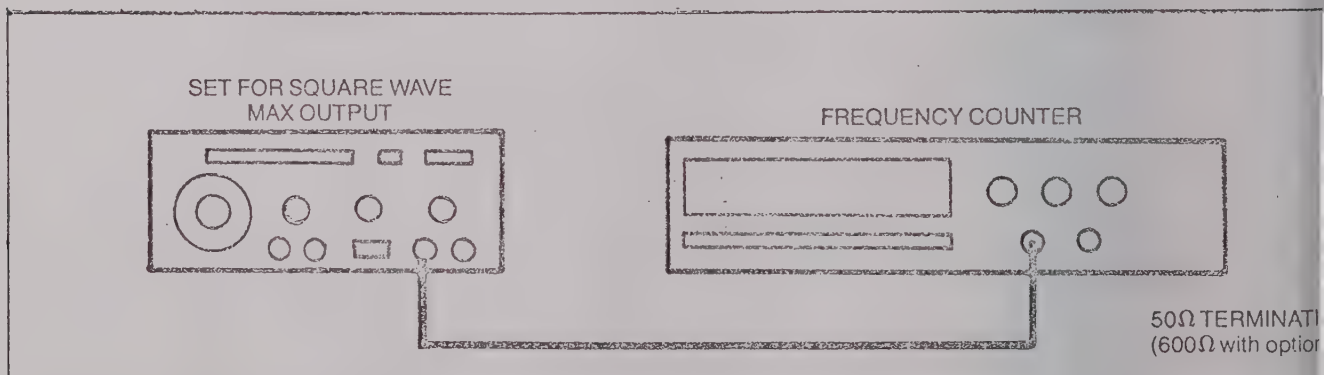


Table 3-2 Frequency Range

Table 3-3 Frequency Range

Range	Multiplier	Frequency Must Be	Time Period Must Be
1M*	Max CW	>2.00 MHz	<0.500 μs
1	<0.20	<0.2000 Hz	>5.000 s

Use the 100k range on instruments with option B. (>200 kHz <5.0 μs)

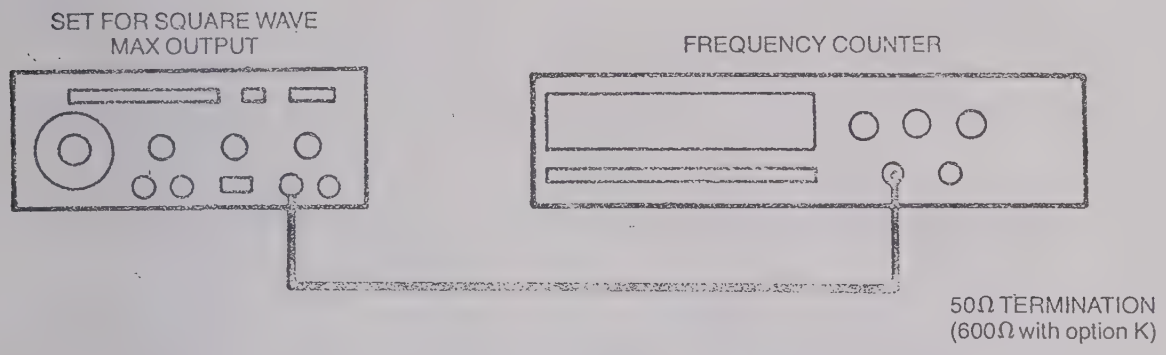


Table 3-4 VCF (Voltage Controlled Frequency)

Range	Mult.	VCF Input Voltage	Voltage Tolerance	Measured Frequency	Measured Time Period
100K	2.0	0V	±250 mV	200 kHz ±5%	5.0 μs ±5%
100K	2.0	See Note: +10 VDC	±1 VDC	200 Hz ±5%	5.0 ms ±5%

Note: Apply a Positive Voltage at the VCF input (Approx +10 VDC) until a Frequency of 200 Hz ±5% is obtained.

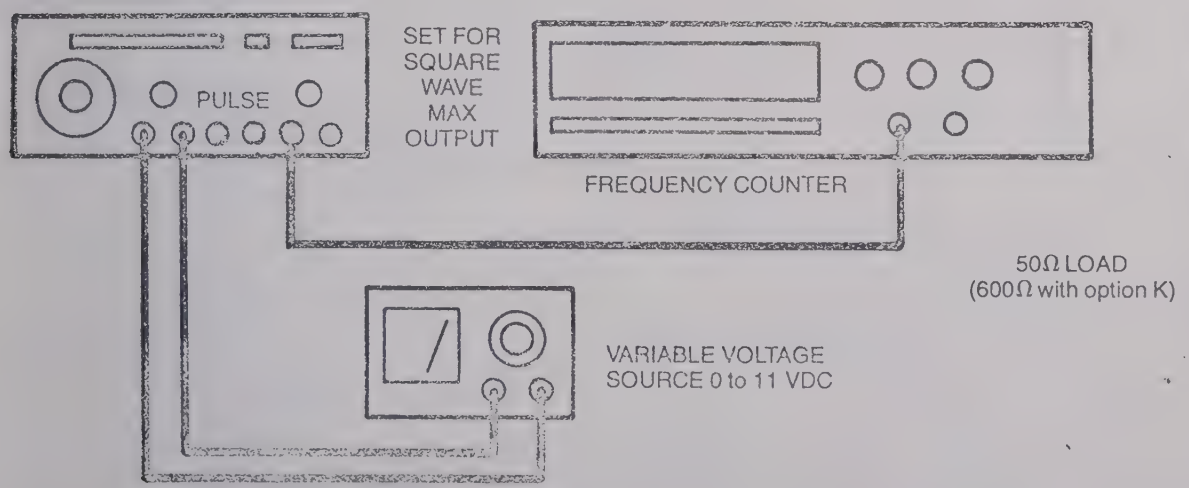


Table 3-5 Main Output Amplitude

Range	Mult	Function	Amplitude	vpp Voltage Tolerance	Output Load
1K	2.0	⊓	Max (CW)	≥20 V P-P	Open Ckt
		∿		≥20 V P-P	
		∿		≥20 V P-P	
		⊓	Min (CW)	≤632 mV P-P	
		∿		≤632 mV P-P	
		∿		≤632 mV P-P	

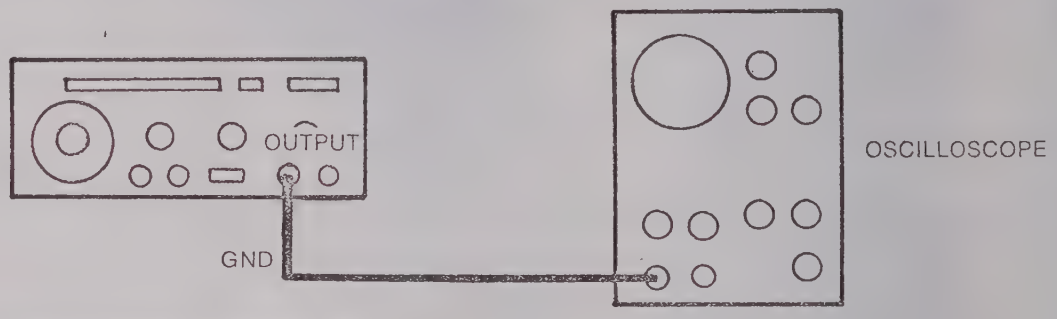


Table 3-6 DC Offset (Main Output)

Range	Mult	Function	Amplitude	DC Offset	Output Voltage Tolerance
1K	2.0	∿	Min (CCW)	Max CW +	≥10 VDC Open Ckt
				Max CCW − but NOT "OFF"	≥−10 VDC Open Ckt
				Max CW +	≥5 VDC into 50Ω Load (600Ω load with option H
				Max CCW − but NOT "OFF"	≥−5 VDC into 50Ω Load (600Ω load with option H

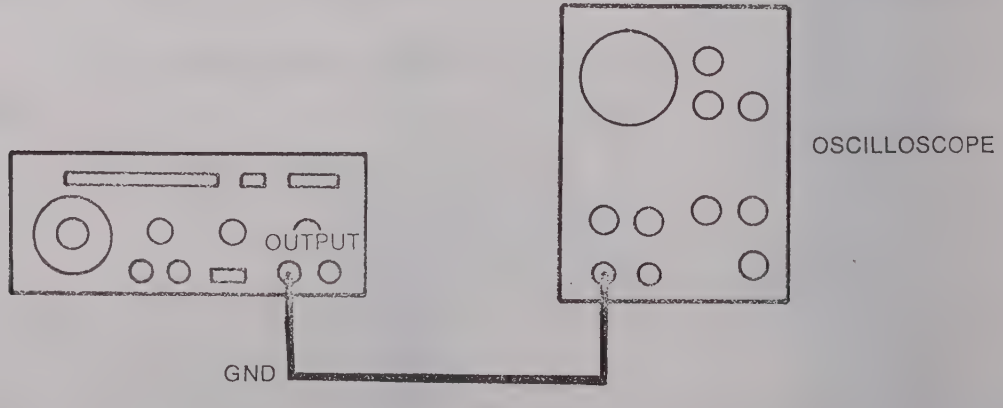


Table 3-7 Sine Distortion

Range	Mult	Function	Measured Sine Distortion	
100K	2.0	~	<1% Sine Distortion	
	0.20			
10K	2.0			
	0.20			
1K	2.0			
	0.20			
100	2.0			
	0.20			
10	2.0			
	0.20			
1	2.0			
	0.20			
1M*	2.0		All Harmonics >30 dB down	Note: Disconnect Distortion Analyzer Before Connecting Spectrum Analyzer
	0.20			

*There is no 1M range with option B.

Table 3-7 Sine Distortion (Continued)

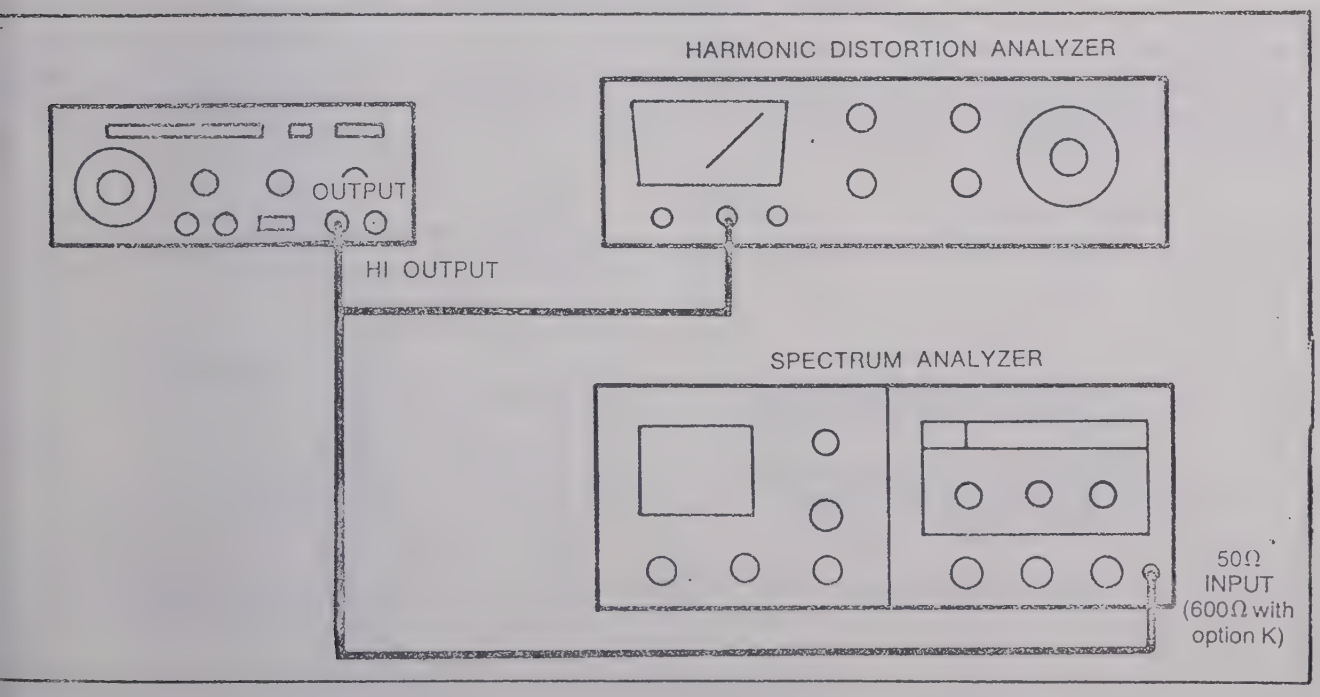
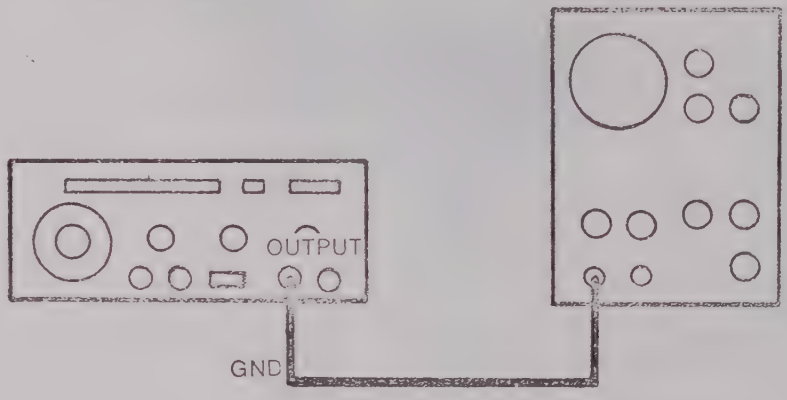


Table 3-8 Sine Frequency Response

Range	Mult	Amplitude	Sine Amplitude	Tolerance
10K	2.0	Max CW	Reference Value	
100K				Reference Value ±0.1 dB (±1.15%)
1M*				Reference Value ±0.5 dB (±5.92%)

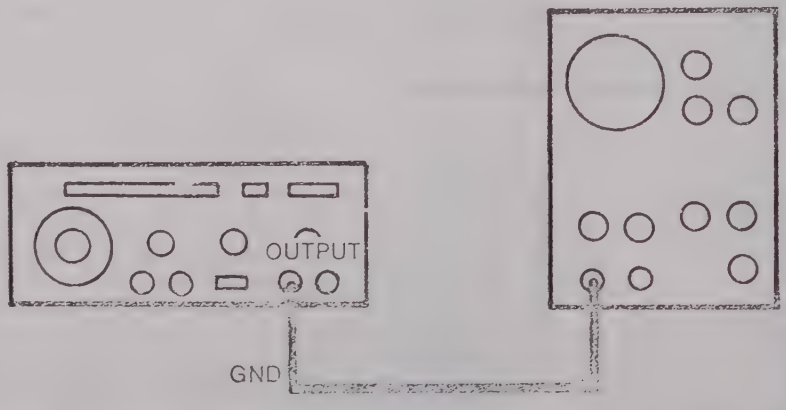
*There is no 1M range with option B



Use 50Ω termination on oscilloscope input (600Ω with option K)

Table 3-9 Squarewave Rise and Fall Time

Range	Mult	Amplitude	Function	Rise Time	Fall Time	Square Aberrations
100K	2.0	10V P-P	⎍	<100ns	<100ns	<±5% of P-P Amp or ±0.5V



Use 50Ω termination on oscilloscope input (600Ω with option K)

Table 3-10 Pulse Output

nge	Mult	Nominal	Pulse Amplitude Range	Maximum Transition Times	Pulse Output Load	Nominal Transition Times
00K	2.0	+3.5V 0V	>+3V <+0.8V	25 ns	Open Circuit	10 ns
		+5V +0.7V	>2.0V <+0.8V	25 ns	20 TTL Loads 131Ω Res From Pulse Output to +5.0 VDC	15 ns

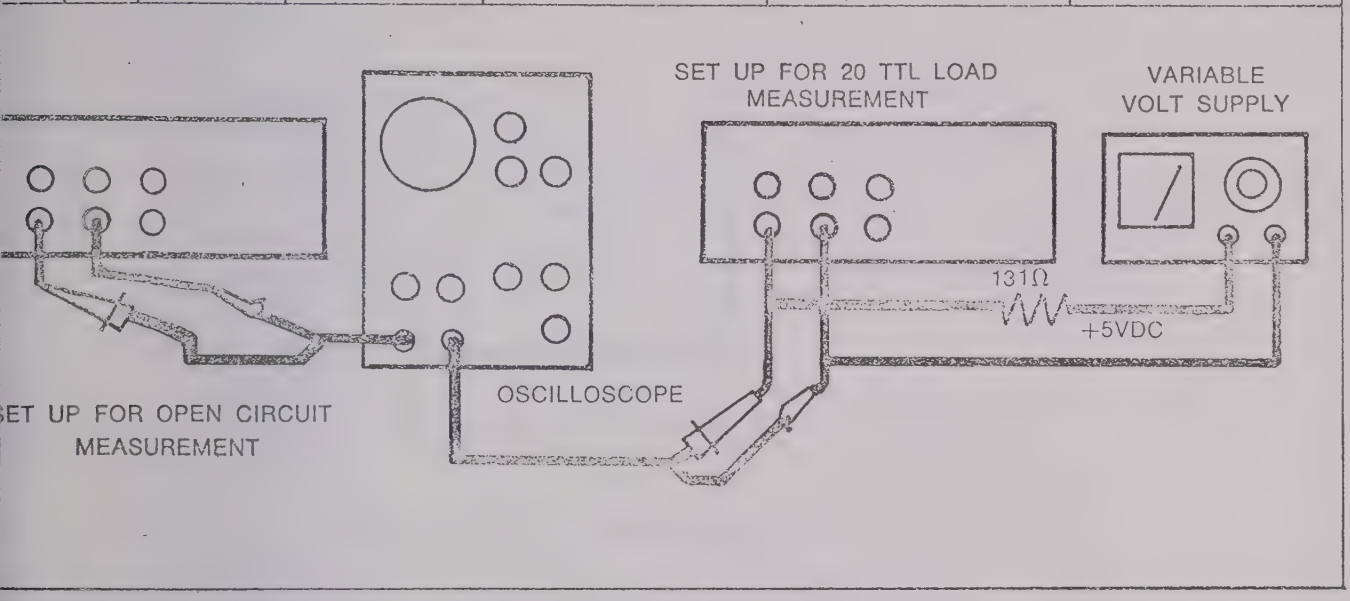


Table 3-11 Ramp Time (Sweep Generator)

Range	Rate	Time Interval Setting	Time Interval Range
1 ms	Cal	1 ms	1.1000 ms to 0.9000 ms
1 ms	Max CCW	>100 ms	>100 ms
100 ms	Cal	100 ms	110.00 ms to 90.000 ms
100 ms	Max CCW	>10 s	>10 s

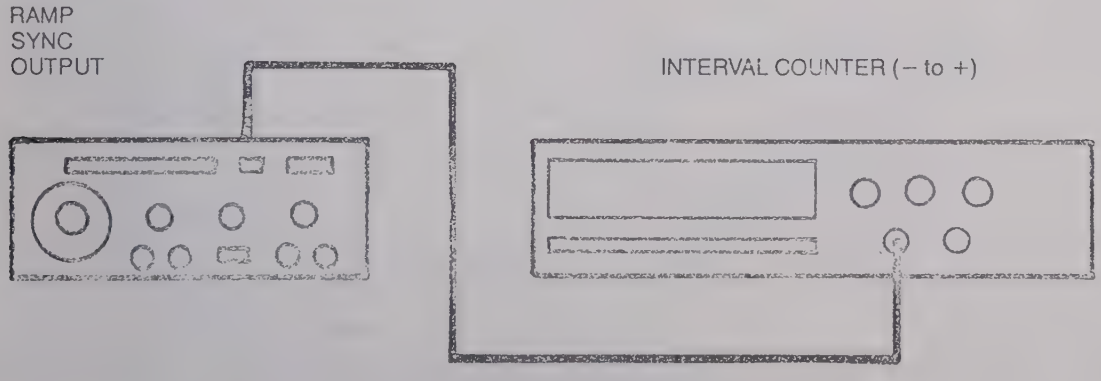


Table 3-12 Sweep Width (Sweep Generator)

Main Generator		Sweep Generator			Sweep Width	Main Generator Frequenc
Range	Mult	Range	Rate	Width >1000:1		
100K	Max CCW	100 ms	Max CCW	Max	3 decades	<200 Hz to >200 kHz

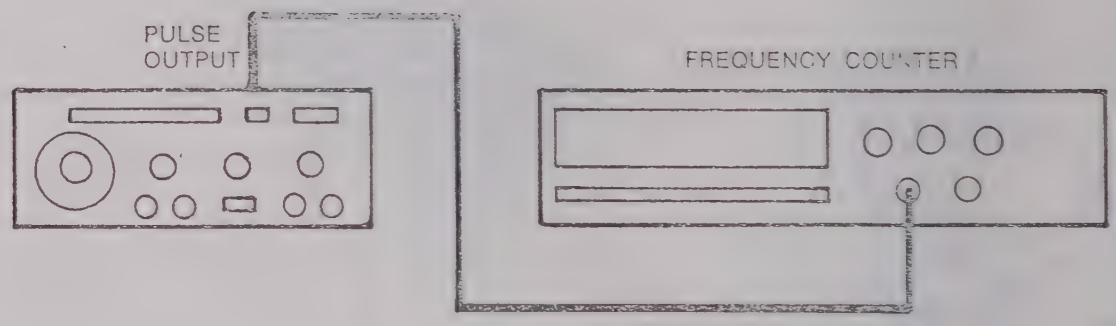
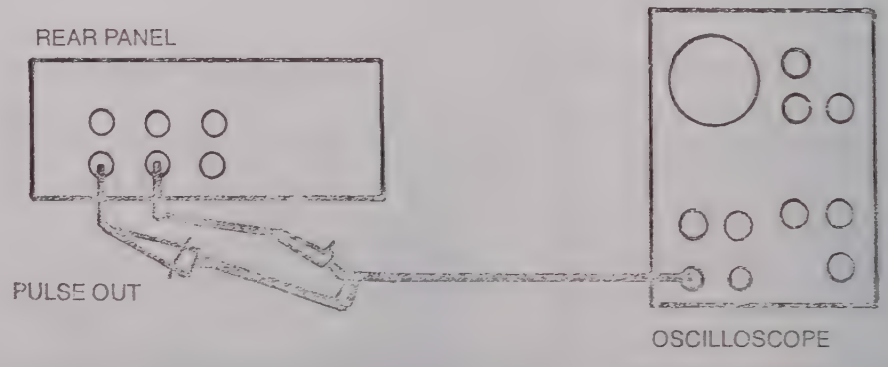


Table 3-13 Ramp Reset Time (Sweep Generator)

Range	Rate	Ramp Time	Reset Time	Reset Time
1 ms	CAL	1 ms ±10%	Approx. 15% of Ramp time	Approx. 150 μs
1 ms	Max CCW	>100 ms	Approx. 0.15% of Ramp Time	Approx. 150 μs



SECTION 4

THEORY OF OPERATION

GENERAL

This section describes the operation in detail as well as a brief description relating to the Block Diagram. (See Section 6). The drawings contained in this section also supplement the schematics in Section 6.

MAIN GENERATOR

A DC voltage from the MULTIPLIER potentiometer is applied to the Summing Amplifier Q200 and Q230. The output of the Summing Amplifier drives the Positive Current Source Q250, Q270, and the Inverter Q220, Q240. The Inverter in turn drives the Negative Current Sourcd Q260 and Q280.

Two constant current sources of opposite polarity charge and discharge a timing capacitor producing the triangle waveform, Fig. 4-1.

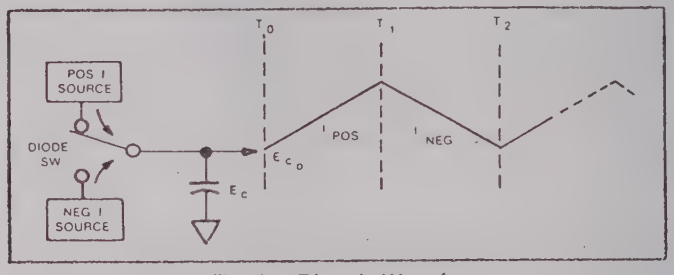


Fig. 4-1 Triangle Waveform

The Positive Current Source charges the timing capacitor during the time period $T_0 - T_1$ causing the voltage on the timing capacitor to increase linearly from T_0 to T_1. At time T_1, the Diode Switch disconnects the Positive Current Source from the timing capacitor and connects the Negative Current Source. The voltage on the timing capacitor will now discharge or decrease linearly until time T_2 when the Diode Switch will disconnect the Negative Current Source and connect the Positive Current Source, etc.

R230A and R230B are equal in value and determine the positive and negative voltages at the Positive and Negative Current Sources. The VAR RAMP/PULSE potentiometer varies the voltage and thus the current of the Positive or Negative Current Source depending upon the position of the RAMP/PULSE switch.

By varying the current from one current source and not the other, the timing capacitor will charge and discharge at different rates and generate an unsymmetrical triangle waveform (Ramp) Fig. 4-2.

MAIN GENERATOR (continued)

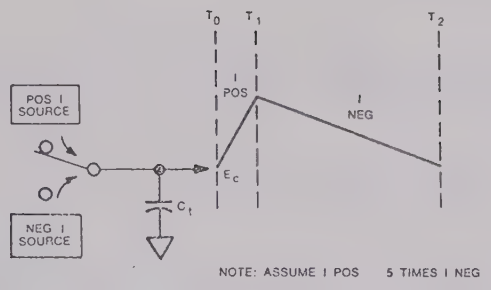


Fig. 4-2 Unsymmetrical Triangle (Ramp) Waveform

The RANGE switch selects different timing resistors and timing capacitors to determine the frequency. A high input impedance BUFFER Q290, Q300A and B prevents loading of the timing capacitor at low timing currents. The triangle waveform is applied to the LEVEL DETECTOR Q300C, D, E, Q330, and Q350. The LEVEL DETECTOR switches when the voltage at its input reaches a predetermined level. The output from the LEVEL DETECTOR causes the Current-Source Diode-Bridge to switch, disconnecting one current source and connecting the other. Connecting and disconnecting the current sources at the proper timing-capacitor voltage produces the triangle waveform. The output from the LEVEL DETECTOR also drives another diode switch to produce a symmetrical squarewave for use at the OUTPUT AMPLIFIER.

A TTL GATE is also driven by the LEVEL DETECTOR squarewave. The output of the TTL GATE provides a TTL pulse at the PULSE OUTPUT connector.

A diode bridge shaping network uses the log curve of silicon diodes to simulate a sinusoidal curve. Fig. 4-3.

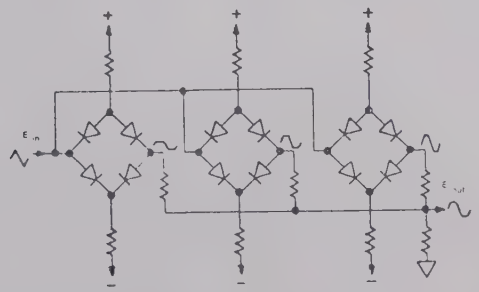


Fig. 4-3 Diode Shaping Bridge

MAIN GENERATOR (continued)

The sine amplifier, Q400, boosts the sinewave amplitude to the proper level for the OUTPUT AMPLIFIER.

A square, triangle, or sine waveform can be selected by the FUNCTION switch. The desired waveform is connected to the AMPLITUDE potentiometer. The OUTPUT AMPLIFIER, Q500 through Q550, is a non-inverting amplifier.

SWEEP GENERATOR (Model 121 only)

The sweep generator uses two operational amplifiers to produce a free-running ramp waveform. One amplifier is an integrator producing the ramp waveform; the second amplifier is a level detector resetting the ramp at the proper time. The ramp waveform is connected to the VCF input of the main generator to provide internal sweep. A transistor provides a Ramp Sync output from the level detector. The ramp waveform from the integrator provides the auxiliary ramp output.

CIRCUIT DESCRIPTION (Main Generator)

The power supply shown in the Block Diagram, Fig. 6-1, consists of a full wave unregulated ± 20V supply and a regulated ± 15V supply.

NOTE: Unregulated ± 20V supply: Refer to the schematic diagram Fig. 6-3.

Line voltage is applied to transformer T100 through power switch S100. The Power On indicator LED (D100) is connected to the -15V DC supply when S100 is in the ON position.

Jumpers B, C, D, and E provide for line voltages of 100, 115, 200, and 230VAC 50-60Hz.

NOTE: If it is necessary to change the wiring on the transformer primary to accept Line voltages other than 115VAC, refer to Section 2 (AC Power Requirements) for the proper procedure. The proper wiring, jumpers, and fuse data for different line voltages are shown on the power supply schematic (Fig. 6-3).

D101, D102, D103, And D104 are a full wave rectifier converting the line voltage to approximately ± 20V DC across filter capacitors C100, C101, C106, and C107.

Q100 is a dual regulator supplying ± 15V DC.

R101 and R102 are current-sensing resistors providing protection in the event of short circuit on one of the supplies. The short-circuit current-limit is set at approximately 200mA. Sine C Adjust balances the ± 15V supplies. This small amount of adjustment (approximately ± 300mV) helps adjust the waveform symmetry for minimum sine distortion.

SUMMING AMPLIFIER

Refer to Fig. 6-4 (Schematic Diagram MODEL 119 and 121 FUNCTION GENERATORS).

Q200 is an operational amplifier. Q230 is an emitter follower buffer used in conjunction with the operational amplifier. Q200 and Q230 are a summing amplifier with a closed loop gain of -1 (inverting). The MULTIPLIER, R202, supplies a negative voltage to the summing amplifier input (pin 2) through summing resistor R206. The negative voltage of approximately -2V to 0V is inverted by the summing amplifier and appears as +2V to 0V at Q230's emitter.

Main Timing potentiometer R203 adjusts the voltage on the MULTIPLIER for frequency calibration. The frequency is dependent upon the voltage of the summing amplifier output. (Q230 emitter).

The frequency may be swept (adjusted) over a three decade range (1000:1) by the MULTIPLIER or by applying the proper AC or DC voltage at the VCF input. With the MULTIPLIER set at 2.0, the voltage at the summing resistor R206 is approximately -2V. By applying approximately +10V DC at the VCF input, +2V is applied at summing resistor R205. The -2V from the MULTIPLIER and the +2V from the VCF input add to provide 0V at the summing amplifier output. This causes the frequency decrease approximately three decades (1000:1). To sweep up in frequency rather than down, set the MULTIPLIER at maximum counter-clockwise (approximately 0V at the summing amplifier output). This sets the frequency approximately three decades below the selected frequency RANGE. By applying approximately -10V at the VCF input, the summing amplifier output will be forced to +2V, causing the frequency to increase three decades (or to the maximum frequency indicated on the selected frequency RANGE). By setting the MULTIPLIER at the desired start frequency and applying the proper AC or DC voltage at the VCF input, the frequency may be swept as desired over a three-decade range.

NOTE: The maximum and minimum frequency limits on any selected frequency RANGE are 0.002 and 2.0 (1000:1) on the MULTIPLIER dial.

Q230 provides a voltage-to-current conversion for driving the positive current source. Q230 converts the voltage at Q230's emitter to a constant current through R230A. Assume VAR RAMP/PULSE control is in the CAL position. By varying the MULTIPLIER the voltage on R231A varies, causing the current through R230A to vary. The current through R231A and R230A are equal except for a small base current for Q230 and bias current for Q220.

INVERTER

The INVERTER (Q220, Q240) inverts the voltage at the summing amplifier output (Q230 emitter) and applies it across R231B which is equal to R231A. Q220 is an operational amplifier connected for a closed-loop gain of -1 (inverting). The +2V at Q230 emitter is inverted and becomes -2V at Q240 emitter. Q240 is an emitter follower buffer used in conjunction with the operational amplifier Q220. The voltage across R231B is equal to the voltage across R231A, therefore the current through R231B is equal to the current through R231A (assuming R250 is in the CAL position). Q240, like Q230, provides a voltage-to-current conversion.

POSITIVE and NEGATIVE CURRENT SOURCE

The positive and negative current sources provide constant currents for charging and discharging the timing capacitors.

Q250 and Q270 form a voltage follower. Q250 is an operational amplifier with very low input bias currents to prevent timing current errors. Q270 is an emitter follower providing the voltage-to-current conversion for the current source.

Q260 and Q280 perform the same function for the negative current source. Equal voltages appear at the current source inputs and outputs depending on the MULTIPLIER setting as previously explained.

Since the currents through R230A and R230B are equal, the voltage at Q250 and Q260 inputs is equal and opposite in polarity. The voltage appearing at Q270 and Q280 emitters is also equal and opposite in polarity.

The timing current is determined by the voltage across the timing resistors (R270 to R273 and R280 to R283).

The RANGE pushbutton switches select the proper timing resistors and capacitors according to the frequency range selected.

VAR RAMP/PULSE

S250 RAMP/PULSE switch and R250 VAR RAMP/PULSE controls are used to obtain pulse and ramp waveforms. When the VAR RAMP/PULSE control R250 is in the CAL position, R231A and R231B are both connected to ground in either position of the RAMP/PULSE switch S250.

As long as R231A and R231B are grounded, the current through them is equal. When the RAMP/PULSE switch is in the NORM position (out), R231A is grounded directly and R231B is grounded through R250, the VAR RAMP/PULSE control. With R250 in the CAL position, currents through R231A, R231B, R230A, and R230B are equal; therefore the voltages at Q270 and Q280 are equal and opposite. A triangle waveform is produced across the timing capacitor. When R250 is not set to the CAL position, the resistance between Q240's emitter and ground is variable from 1K Ohm to approximately 20K Ohms. The voltage at Q240's emitter remains constant as determined by the MULTIPLIER setting. This causes the current through R231B to vary over approximately a 20:1 range; approximately 2mA in the CAL position (1K) and approximately 0.1mA in the CW position (20K). Current through R231A remains constant while current through R231B is variable. The positive current-source voltage remains fixed and the negative current-source voltage is variable by the VAR RAMP/PULSE control. A variable-slope ramp waveform is produced in this manner. The slope of the ramp is adjusted as desired over approximately a 20:1 range. When the RAMP/PULSE INVERT switch (S250) is set to the INVERT position, the positive current source becomes variable and the negative current source remains fixed, reversing the slopes of the ramp waveform. NOTE: When R250 is in the CAL position, the position of S250 has no effect because R231A and R231B are both grounded in either position of S250.

CURRENT-SOURCE DIODE-SWITCH

A diode switch connects and disconnects the current sources. Output from the level detector sinks the current from either the positive or negative current-source. When the input to the switching bridge is positive, the level detector sinks the current from the negative current source through diodes D281 and D280. This positive input signal reverses biases D273 and D272. The positive current-source now charges the timing capacitor positive. When the voltage on the timing capacitor reaches approximately +1V, the level-detector switches and the diode-bridge input switches negative. This negative voltage at the input to the switching bridge sinks the current from the positive current-source through D273 and D272. It also reverses biases D281 and D280. The negative current-source now discharges the timing capacitor. When the voltage on the timing capacitor reaches approximately -1V, the level-detector switches and the timing capacitor charges positive again, etc.

BUFFER

Q290, Q300A, and Q300B form the high input impedance buffer. Q290 is a FET with a very high input impedance. Q300B is a current source supplying bias current for Q290. The ZERO BAL adjust R303 sets the bias current through the FET (Q290) to the proper level to obtain a gate-to-source voltage equal to the base emitter drop of Q300A. The gate-to-source voltage of the N-channel FET Q290 is opposite in polarity to that of the emitter follower Q300A. The input-to-output offset thereby is adjusted to 0V. The emitter follower output (pin 10) drives the level detector and associated circuitry.

LEVEL DETECTOR

The level detector senses the voltage on the timing capacitor (the buffer output) and switches the diode switch to produce the triangle waveform. Q300C and D form a differential amplifier. Q330E is a current source. Q330 and Q350 form a second differential amplifier driven from the input differential amplifier Q300C and D. Positive feedback is applied to Q300D's base through the reference switching bridge (D330 - D333). This positive feedback and high open-loop gain provide very fast switching for the level detector. Q330's collector drives the reference switching-bridge to provide the positive and negative reference current through R308. When Q330 is on, the collector holds the reference bridge input positive. Q330 sinks the current from the negative supply through R335, R333, and D333. Current through R308, D330, R331, and R330 establishes the positive reference voltage (approximately +0.5V) at Q300D's base. Q330's collector is also connected to the current-source switching-bridge at the junction of D273 and D280. This positive signal allows the timing capacitor to charge in the positive direction as explained in Section 4 (Theory of Operation).

The level detector input is voltage divider R304 and R305. +1V at R304's input equals approximately +0.5V at Q300C's base. When the voltage at Q300C's base rises above the reference voltage at Q300D (+0.5V), the level detector switches. Q330 will turn off, causing the voltage at the reference bridge (D330 to D333) and the current-source switching-bridge (D270 to D273 and D280 to D283) to switch negative. This negative voltage causes the reference voltage at Q300D

LEVEL DETECTOR (continued)

to switch negative and the timing capacitor to begin charging negative (discharge). When the timing capacitor has charged to approximately -1V, the signal at Q300C is more negative than the reference voltage at Q300D (now approximately -0.5V) and the level detector switches again, etc. Q350's collector supplies the squarewave signal to drive the Square Diode-Switch and the TTL Gate Q360.

TTL GATE

Q360 is a Dual, 4-Input, Positive Nand-gate providing the TTL PULSE OUTPUT. D360, D361, and D362 provide the necessary level shifting of the squarewave from Q350's collector to drive the TTL GATE inputs (pins 1 and 9). D363 is a zener diode providing a +5V power supply for the TTL GATE. The two nand-gate outputs (pins 6 and 8) are paralled to provide the capability of sinking 20 TTL Gates.

The TTL GATE output levels are approximately +3V and 0V open circuit at 10nS (typical) rise and fall times. The PULSE out is a squarewave as long as the VAR RAMP/PULSE control is in the CAL position. A variable pulse width and variable-duty-cycle pulse are easily set up using the VAR RAMP/PULSE control and RAMP/PULSE INVERT switch as shown in Section 2, Table 2-1.

SQUAREWAVE DIODE SWITCH

The squarewave diode-switch (D356 to D359) provides a clean squarewave of approximately ±1V from the ± 2V signal at Q350's collector. The signal from Q350's collector is routed through FUNCTION Switch S500C, activating the diode switch only when the squarewave is selected. The positive signal sinks the current through D358 and R353. The positive portion of the squarewave is developed across the amplitude potentiometer (R508) through R354, D357, and R352. The negative portion of the squarewave is developed across R508 through R354, D359, and R353, when the squarewave at Q350's collector reverses polarity. R354 provides a small adjustment to calibrate the squarewave amplitude.

SINE SHAPER

Three diode bridges produce a sinewave from the triangle waveform. D400, D401, and D402 are three matched sets of 4 diodes each. The triangle waveform from the buffer output is connected to these three diode bridges through R400. As the triangle voltage rises above 0V, the current through R404 increases exponentially in the positive direction through D400B and R402 while the current through D400D and R401 is being shunted through D400C. When the triangle has reached its positive peak, the current through R404 to the +15V supply has reached maximum. The current now decreases exponentially as the triangle rises toward its negative peak. When the triangle has reached approximately 0V, the current through R404 is nearly zero because an equal current is passing through D400D and D400B. As the triangle increases in the negative direction, current increases through D400D and R404 exponentially. Current through R402 is now being shunted through D400A as the triangle rises toward its negative peak. The current through R404, R406, and R409 increase in the positive and negative direction exponentially through each of the three bridges in the same manner. The current through each bridge is determined by their respective resistors, the exponential currents of the three bridges are summed, or added, into R410 to produce a sinewave. The distortion is typically 0.5%

SINE AMPLIFIER

Q400 is an operational amplifier boosting the small sinewave at R410 to approximately 2V P-P. This amplifier is connected as an inverting amplifier with a closed-loop gain of approximately -6. R416 adjusts feedback to set the sinewave amplitude. The sinewave is then connected to the AMPLITUDE control, R508, when the sinewave is selected by the FUNCTION switch, S500.

OUTPUT AMPLIFIER

± 20V P-P waveforms are produced by the output amplifier. Squarewave rise and fall times <100nS are provided with this amplifier's 200V/µSec slew rate. Q500 and Q510 form the input differential amplifier. Feedback for this non-inverting amplifier is through R505. R505 and R504 form a voltage divider at Q510 (the inverting input), establishing a closed-loop gain of approximately 10. Q520 and Q530 are constant-current sources driving bias diodes D520 and D530. R522, R523, and R531 are a voltage divider providing the bias voltage for Q520 and Q530. R530 sets the current for Q530 a few milliamps less than the current for Q520. Q510 supplies a current equal to the current difference between Q520 and Q530. Q540 and Q550 form a complementary-output emitter-follower. A positive-going signal at Q500's base will cause Q500's collector current to increase and Q510's base will cause Q500's collector current to increase and Q510's collector current to decrease. A decrease in current from Q510 causes excess current from the Q520 current source to raise the voltage at Q540's, and Q550's bases. Negative feedback from the output emitter-followers through R515 to the base of Q510 maintains an output signal 10 times the input signal. As the input signal becomes negative, Q500's collector current decreases and Q510's collector current increases. As Q510's collector current increases, the current from Q520's collector becomes less than the current from Q530 and the output follows the input negative. Negative feedback maintains the output at 10 times the input signal as previously explained. R542 and R543 provide a 50 Ohm output impedance and short-circuit protection.

LO OUTPUT

R544 to R548 make up the output attenuator for the LO OUTPUT.

ATTENUATOR (Option A)

The LO OUTPUT is replaced by a switch providing 0-20-40dB attenuation.

SWEEP GENERATOR (Model 121 only)

INTEGRATOR

Q700 is an operational amplifier used as an integrator. Timing current is supplied from the rate control (R702) and timing resistor (R701). R704 (Ramp Timing) adjusts the ramp duration during calibration. A bottoming resistor (R703) limits the Variable Sweep Rate to 100:1.

C701 and C702 provide two sweep rate ranges (1mS and 100mS).

INTEGRATOR (continued)

The timing current is supplied from the +15V supply. The integrator output charges the timing capacitor negative at a rate determined by the RATE control setting and the selected timing capacitor. When the integrator output reaches approximately -2.5V, the level-detector switches negative. Q710 turns on through R710, discharging the timing capacitor at a much faster rate, providing a reset time of about 15%.

LEVEL DETECTOR (Model 121)

Q720 is an operational amplifier connected as a level detector.

Assume Q720's output is NEGATIVE initially. Q710 will turn on causing the integrator output to charge positive (ramp reset). The negative output of Q720 reverse biased by approximately -12V. Pin 2 of Q720 is grounded. The output of Q720 will remain negative until the input on Pin 3 becomes more positive than Pin 2. When the Ramp has reset to approximately 0V, the output of Q720 will switch positive.

When Q720 switches positive, Q710 is turned off allowing the integrator output to charge negative. The positive output of Q720 also reverse biases D721. With D721 reverse biased, R721 provides a positive input current to Q720 Pin 3. The output of Q700 now charges negative until the negative input current through R720 is greater than the positive input current through R271. Q720 then switches negative, turning on Q710, etc. R720 and R721 establish the ramp amplitude at approximately -2.5V.

MODULATOR (Model 119M only)

When in the AM mode, the modulator circuitry is inserted between the FUNCTION switch and the AMPLITUDE control. U1 is a 4 - Quadrant multiplier. The signal from the FUNCTION switch is the carrier and is applied to one input of U1. The modulating signal from the AM INPUT is applied to the other input. When the CARRIER control is centered, it applies 0V to U1 pin 8. U1 is then a balanced modulator, suppressing the carrier when there is no voltage at the AM INPUT. When the CARRIER control is not centered, it applies a voltage to pin 8 and U1 then is an amplitude modulator.

The differential output of U1 is applied to the inputs of differential op-amp U2. U2 shifts the level to remove DC offset and converts the signal to a single-end output. The output is then applied to the AMPLITUDE control.

When the generator is not in the AM mode, the signal from the FUNCTION switch bypasses the modulator.

RESET (Model 121)

Q710 provides a fixed reset-current to reset the ramp waveform. This current provides approximately a 15% reset time when RATE is set for maximum timing current (CAL position). When RATE is set fully CCW (100:1) the timing current is 100 times smaller than in the CAL position. This then provides a reset time of approximately 0.15%.

RAMP SYNC (Model 121)

Q730 provides a +5V (approximately) pulse output coincident with the reset of the ramp. When Q720's output is positive, Q730 will be turned 'on', pulling the Ramp Sync output signal near ground. When Q720's output is negative, Q730 will be reverse biased. R731 and R732 are voltage divider providing approximately +5V at the Ramp Sync output when Q730 is 'off'.

RAMP OUTPUT (Model 121)

The negative ramp from Q700 is connected to the Ramp output through R740.

MODEL 119L

RESET BUFFER

Q805 provides a logic pulse of proper polarity to drive the Trigger Gate Logic without loading the Bi-stable Switch.

LOCKOUT AMPLIFIER

The Lockout Amplifier is a differential amplifier which compares the triangle waveform to a fixed reference established by the Start Level Adjustment (R829). Q801 and Q802 form the input stage which drives Q803 and Q804, the output stage. D802 is a Zener diode used as a collector clamp for Q801 to keep it out of saturation. Q804 collector is connected to D803, the lockout diode connected to the Current Source Gate at the input of the triangle buffer.

D804 enables and disables the output stage. During Run, D804 is forward biased, keeping Q804 turned off. With Q804 off, D803, the lockout diode, is reverse biased and the generator free runs. During lockout, D804 is reverse biased, enabling the Lockout Amplifier. As the triangle charges toward its negative peak, Q801 becomes reverse biased until Q801 turns off sufficiently to cause Q804 to turn on. When Q804 turns on sufficiently, it will forward bias D803, sinking the timing current from the Negative Current Source. The level at the point of lockout is determined by the input divider to the Lockout Amplifier, R801, R829, and R802.

MAIN GENERATOR LOCKOUT LOGIC GATE

U801D is a Quadruple 2 Input Positive Nor Gate, which provides the necessary logic function to operate the Lockout Amplifier. In the Run Mode of operation, the Trigger Level Comparator supplies a logical "1" at one input of U801D pin 12. As long as this logical "1" is present, the output of U801D pin 13 will remain a "0". A "0" at pin 13 will forward bias D804, disabling the Lockout Amplifier, causing Q804 to remain "off", or in a run condition, as previously explained. In the Gate Mode of operation, the Trigger Level Comparator supplies a "0" to the logic input U801D pin 12. The output will remain a "0", keeping D804 forward biased in the Run Mode until a "0" is applied at the other input, pin 8.

The pulse from the Reset Buffer is coincident with the square wave from the Level Detector. When the square is in the proper phase relationship, a negative pulse

MAIN GENERATOR LOCKOUT LOGIC GATE (continued)

or "0", from the Reset Buffer is connected to the other logic input pin 8, which will cause the output of U801D pin 13 to go to a logical "1", thus reverse biasing lockout diode D804. D804 will remain reverse biased in a lockout condition until one of the logic inputs goes to a logical "1" level or positive. The Reset Buffer during lockout will remain a "0" as long as the generator is locked out.

TRIG LEVEL COMPARATOR

U802 is a high speed differential comparator providing DC coupled Triggering, Gating, and Bursting Modes for the Main Generator Logic Gate.

RUN mode:
In the Run Mode, -15V is applied to the inverting input of U802 through R819. This assures that the non-inverting input always remains more positive than the inverting input. This causes U802 output to remain positive or in the Run Mode of operation. Both inputs of the comparator are protected by clipping diodes D807 through D810.

GATE mode:
In the Gate mode, the -15V from S801A is disconnected, causing U802 inverting input, pin 3 to go to a more positive state than the non-inverting input. This switches the output of the comparator to its negative or "0" state. The "0" from the comparator places the Logic Gate in a lockout condition. The generator will remain in a lockout condition until signal is received at the comparator input, pin 2.

In the Gate Mode, the comparator input is connected to the External Trigger Input. Any signal greater than trip level of the Comparator will place the Logic Gate in a "run" condition. When the input signal is removed, the comparator will allow the Logic Gate to return to its lockout condition.

TRIGGER mode:
The only difference between the Gate and Trigger modes of operation is that the output of the comparator is AC coupled to the Logic Gate instead of DC coupled. When the trigger signal causes the comparator to turn on, the positive output of the comparator AC couples a differentiated positive pulse into the Logic Gate, placing it in a run condition. The duration of this pulse is very short, allowing the Logic Gate input to return to a "0" or a lockout condition even though the comparator may still be "on" in its positive state. The Reset Buffer will couple a "0" into the Logic Gate upon completion of the first cycle and cause the generator to lock out. The external trigger signal must be removed, allowing the comparator to reset before another pulse can be coupled into the Logic Gate. One complete cycle will be generated each time a signal is applied at the Trigger Input.

MANUAL GATE/TRIGGER SWITCH

The Man Pushbutton switch located on the front panel is used in conjunction with the Man Gate/Trig Switch to provide a bounce-free switch for manually gating and triggering the Main Generator and Ramp Generator. U801A and B are one-half of a Quadruple 2 Input Positive Nand Gate. Normally, S801C, the Manual Pushbutton, keeps one input of the Nand Gate, U801 pin 2 at "0" and pins 3 and 4 at "1". Pin 5 is connected to +5V or a "1" through R828. With both inputs of U801B Positive Nand Gate at "1", the output, pin 4 will remain at "0". The output of this Positive Nand Gate is connected through D811 to the Trigger Level Comparator. When S801C, the Man Pushbutton, is depressed, pin 5 of U801B Positive Nand Gate will be set to "0". This will cause the output, pin 4, to go to a "1" or positive state. This "1" is coupled through D811 to the Trig Input. This "1" will remain until S801C is released, allowing the output of U801B to return to a "0".

SECTION 5

MAINTENANCE, CALIBRATION, AND TROUBLESHOOTING

DISASSEMBLY FOR CALIBRATION

(a) Remove the retaining screws on the rear bezel which secure the top cover, Fig. 5-1.

(b) Push up on the two tabs from which the retaining screws are removed to loosen the cover. Lift the rear of the top cover away from the rear bezel, Fig. 5-2.

(c) Push the cover away from the front bezel, Fig. 5-3.

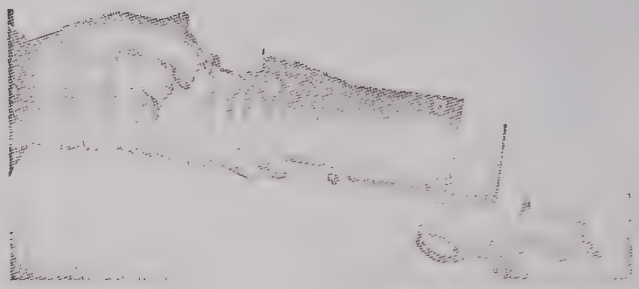


Fig. 5-1 Retaining Screw Removal

Fig. 5-2 Top Cover – Mounting Tabs Removed from Rear Bezel

Fig. 5-3 Top Cover Removal

This provides access to all Model 119 calibration adjustments. To access the Model 119M and 121 calibration adjustments, remove the bottom cover in the same manner.

DISASSEMBLY FOR PARTS REPLACEMENT

Remove the top and bottom cover as described under disassembly for calibration. With the top and bottom covers removed, both sides of the printed circuit board are accessible for parts replacement or troubleshooting.

REASSEMBLY

The top and bottom covers are reassembled simply by reversing the disassembly procedure.

CALIBRATION

Required equipment: The equipment required for calibration is listed in Table 3-1.

Preparation for Calibration: Perform Section 5 (Disassembly for Calibration).

Apply power to the generator and allow at least 30 minutes warm-up time.

All adjustments are labeled on the top of the PC boards to help locate them. Refer also to Fig. 5-4, Fig. 5-5, and Fig. 5-6 (Adjustment Location).

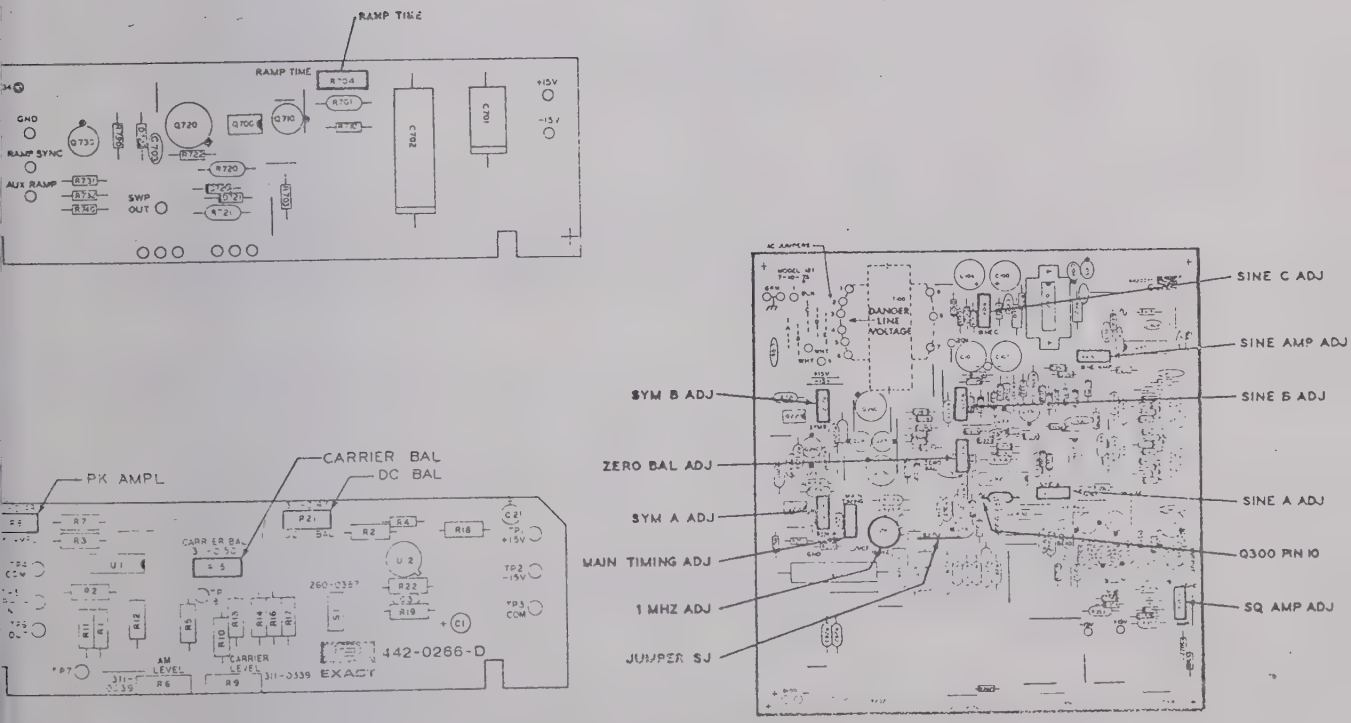


Fig. 5-4 Adjustment Locations

PROCEDURE

Set all controls as follows unless otherwise indicated:

POWER	ON	
RANGE-HZ	1K	
MULTIPLIER	2.0	
RAMP/PULSE	NORM (OUT)	
FUNCTION	SINE	
VAR RAMP/PULSE	CAL	
DC OFFSET	OFF	
AMPLITUDE	MAX (CW)	
ATTENUATOR (Option A)	0dB	
WIDTH	OFF	
RATE	CAL	121 ONLY
SWEEP RANGE	1mS	121 ONLY
AM	OFF	121 ONLY
CARRIER	'0'	119M ONLY
MODULATION	OFF (CCW)	119M ONLY
RUN	IN	119L ONLY
START LEVEL	CENTERED	119L ONLY

ZERO BALANCE

Connect a jumper from the main output ground to the jumper marked SJ (summing junction) on the PC board, Fig. 5-4. Using a voltmeter, DVM, or oscilloscope, adjust ZERO BAL to obtain DV = 25mV at Q300 pin 10, Fig. 5-4. Remove the jumper and proceed with the next step.

1000:1 SYMMETRY ADJUST

Set the MULTIPLIER to the MAX CCW end of rotation. Select the 100kHz RANGE and the triangle waveform. Observe the triangle waveform on an oscilloscope connected to the main OUTPUT. Set the horizontal sweep rate of the oscilloscope to 0.5mS/Div.

Adjust SYM A and SYM B to obtain one complete symmetrical triangle across the CRT (10 Div).

NOTE: 5mS = 200Hz (1000:1)

SINE DISTORTION

Connect a distortion analyzer to the main OUTPUT and monitor the harmonic distortion.

Adjust Sine A, B, and C adjusts to obtain minimum sine distortion. Typically <0.5%.

MAIN TIMING

(a) Connect a frequency counter to the PULSE output and monitor the frequency.

With the MULTIPLIER set at 2.0 and the 1K RANGE selected, adjust the MAIN TIMING to obtain *2kHz ± 1%.

NOTE: Be sure the VAR RAMP/PULSE CONTROL is in the CAL position.

(b) Set the MULTIPLIER to 0.2 and observe *200Hz ± 10% on the frequency counter.

NOTE: If the frequency at the 0.2 end of the MULTIPLIER is out of tolerance, or it becomes necessary to re-set the MULTIPLIER knob; refer to Section 5 (multiplier alignment procedure) for the proper procedure to re-align the MULTIPLIER knob.

(c) Select the 1M RANGE and set the MULTIPLIER to 2.0. Adjust the 2MHz trimmer capacitor to obtain *2MHz ± 1%.

* This is tighter than the 5% of full scale specification.

OUTPUT AMPLITUDE

Select the 1K RANGE. Connect an oscilloscope to the main OUTPUT and observe a triangle waveform 20V P-P open circuit.

Select the sine waveform and adjust the SINE AMPLITUDE for 20V P-P.

Select the square waveform and adjust the SQ AMP adjust for 20V P-P.

NOTE: A small amount of DC offset may exist from one waveform to another, however, the DC OFFSET control allows the DC level of all waveforms to be set as desired.

RAMP TIMING (Model 121 only)

(a) Connect a timer/counter to the Ramp Sync output. Set the counter to measure the interval from - slope to + slope.

(b) Adjust the Ramp Timing adjust (Fig. 5-5) to obtain 1mS ± 10% and 100mS ± 10% with the RATE control in the CAL position.

CALIBRATION PROCEDURE (M Option)

Connect an oscilloscope to HI OUTPUT.

1. With the AM switch OFF, set FUNCTION to triangle, AMPLITUDE to full scale, (ATTENUATOR to "0dB", for Model 119M), RANGE to 100Hz, dial to 2.0, VAR RAMP/PULSE to CAL, MODULATION fully CW.

CALIBRATION PROCEDURE (M Option) (Cont.)

2. Adjust DC OFFSET control for symmetrical peaks about ground ± 100mV.

3. Depress AM switch, adjust CARRIER level for minimum signal at output. Locate "DC BAL" adjustment on the AM board, and set it for 0V at OUTPUT, ± 50mV DC.

4. Rotate CARRIER level from CCW to CW several times as necessary, adjusting "CARRIER BAL" on AM board for equal DC levels.

5. Rotate CARRIER CCW, and record voltage P-P. Rotate CARRIER CW, and do the same. Adjust "Peak Amplitude" for the larger of the two P-P readings. Amplitude should be the same as when the AM switch is off.

TROUBLESHOOTING

A troubleshooting chart of symptoms and probable causes is provided, Table 5-1.

The table indicates the circuit most likely at fault and test points to check for proper operating voltage and waveforms. The pages of the theory section describing the circuit operation are also indicated.

PROCEDURE

(a) Determine the exact nature and extent of the problem by performing the SPECIFICATION VERIFICATION PROCEDURE in Section 3 and noting which instrument operations fail to perform properly.

(b) With power removed, perform the disassembly procedure described in Section 5, (Disassembly for Calibration).

(c) According to the information obtained in step (a), find the symptoms in Table 5-1 most nearly describing the problem observed. Then perform the appropriate troubleshooting operations.

OTE: The data provided in the troubleshooting chart is with the controls set as llows:

POWER	ON	
RANGE	1K	
MULTIPLIER	2.0	
RAMP/PULSE	NORM (OUT)	
FUNCTION	∿	
VAR RAMP/PULSE	CAL (MAX CCW)	
DC OFFSET	OFF	
AMPLITUDE	MAX	
ATTENUATOR (Option A)	0dB	
WIDTH	OFF	
RATE	CAL	121 ONLY
SWEEP RANGE	1mS	121 ONLY
AM	OFF	119M ONLY
CARRIER	'0'	119M ONLY
MODULATION	OFF (CCW)	119M ONLY
RUN	IN	119L ONLY
START LEVEL	CENTERED	119L ONLY

Table 5-1 Troubleshooting Procedure

Symptom	Probable Cause	Circuit	Test Point	Signal	Reference Page No
No Power On Indication	No Power	Power Supply	+20V	+20V ±5V	31, 5
			−20V	−20V ±5V	
			+15V	+15V ±1V	
			−15V	−15V ±1V	
No Output	Faulty Component	Output Amplifier	Q500 Base	∿ 1V P-P	36, 5
			Q520 Emitter	+12.8 VDC	
			Q530 Emitter	−13 VDC	
			Q540 Collector	+14.9 VDC	
			Q550 Collector	−14.9 VDC	
	Generator Loop Not Running	Current Sources Buffer and Level Detector	Q270 Emitter	+9 VDC	33, 5
			Q280 Emitter	−9 VDC	
			Q230 Collector	+9 VDC	33, 5
			Q240 Collector	−9 VDC	
			Q230 Emitter	+2.2 VDC	
			Q290 Gate SJ	±1V	34, 5

Table 5-1 Troubleshooting Procedure (Continued)

Symptom	Probable Cause	Circuit	Test Point	Signal	Referen Page Nun
No Output Cont'd .	Generator Loop Not Running	Current Sources Buffer and Level Detector	Q300A Emitter	±1V	
			Q300C D Collector	+4.35 VDC	34, 5
			Q300 C D Emitter	−0.5 VDC	
			Q300, Q350 Emitter	+4.78 VDC	
No Output 119M only	AM switch engaged With CARRIER control centered and no modulating signal				
	AM Switch defective	Modulator	TP5, TP6 (AM switch)	2V P-P	37, 3
	Modulator Components	Modulator	U2 pin 6	up to 2V P-P	37,
			U1 pin 2	up to 350 mV P-P	

(Continued on Next Page)

Table 5-1 Troubleshooting Procedure (Continued)

mptom	Probable Cause	Circuit	Test Point	Signal	Reference Page No.
Output veforms lipped	Excessive DC Offset	Output Amplifier	R501 Slider	0V ±0.5 VDC	36, 55
			Q510 Base	~ ±0.5V	
			Q500 Base	~ ±1V	
	Low Voltage	Power Supply	See Power Supply		31, 56
inewave, ngle & are OK	Faulty Component	Sine Amplifier	R419	~ 2V P-P	35, 36, 55
			R410	~ 150 mV P-P	
			Q400 pin 3 & 4	0V ±250 mV	
			R400	~ 2V P-P	
	Intermittent Function SW	S500	S500A NO	~ 2V P-P	36, 55
			S500A arm	~ 2V P-P	
Square Wave iangle Sine Ok	Faulty Comp	SQ Wave Diode Switch	D356 Cathode	⎍ 4V P-P	35, 55
			D357 Cathode	⎍ 2V P-P	
	Intermittent Function SW	S500	S500D Arm	⎍ 4V P-P	
			S500D N.O.	⎍ 4V P-P	
			S500C N.O.	⎍ 2V P-P	
			S500C Arm	⎍ 2V P-P	
e Output	Faulty Comp	Pulse Output	D360 Cathode	⎍ ±2V	55
			Q360 Pin 1 & 9	⎍ +1.6V 0V	
			Q360 Pin 14	+5V ±0.5V	
			Q360 Pin 6 & 8	⎍ +3V 0V	
EL 121 ternal eep, ernal ep OK	Multiplier Set at 2.0	Internal Sweep Generator Sweeps Up Only			
	Width Control In Off Position				
	Defective Switch	Sweep Generator	S722 Contacts	Width Control Max. −2.5V 0V	36, 59
	Defective Component	Sweep Generator	Aux. Ramp Out.	Width Control Max. −2.5V 0V	

m	Probable Cause	Circuit	Test Point	Signal	Reference Page No.
o lation	No signal applied to AM INPUT	A modulating signal must be applied from an external source			
only	MODULATION control in off position				
	U1 defective		U1 pin 4	Up to 5V P-P	59

MULTIPLIER ALIGNMENT PROCEDURE

If it becomes necessary to re-align the MULTIPLIER knob with the potentiometer shaft for any reason, perform the following:

POWER	ON
RANGE	10K
VAR RAMP/PULSE	CAL
DC OFFSET	OFF

(a) Connect a frequency counter to the PULSE output and monitor the frequency.

(b) Loosen the two allen screws in the MULTIPLIER knob and remove the knob and dial skirt assembly from the MULTIPLIER potentiometer shaft. Fig. 5-6.

(c) Rotate the potentiometer shaft CCW until a frequency of 2kHz ± 1% is obtained.

(d) Place the MULTIPLIER knob and dial skirt on the shaft with the index mark on the front panel. Fig. 5-7.

(e) Tighten one allen screw while holding the dial skirt in alignment with the index mark. NOTE: Be sure the frequency counter reads 2kHz ± 10% before tightening the allen screw.

(f) Set the MULTIPLIER to 2.0 and adjust the MAIN TIMING to obtain 20kHz ± 1% if necessary.

(g) In some cases, it may be necessary to repeat steps (b) through (f) until both ends of the MULTIPLIER dial read correctly.

(h) Tighten the remaining set screw.

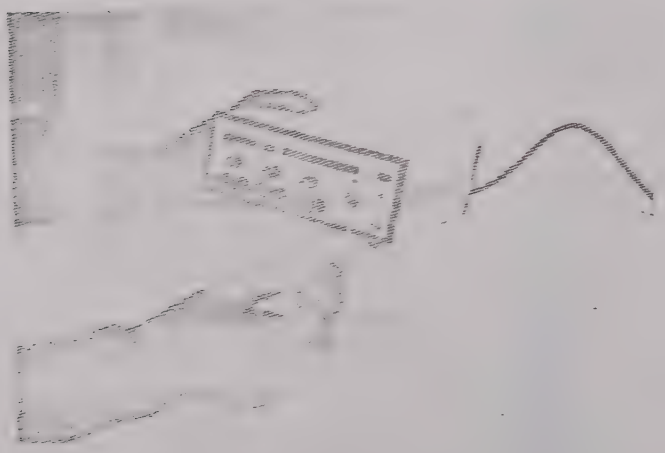


Fig. 5-5

Removal of Multiplier Knob

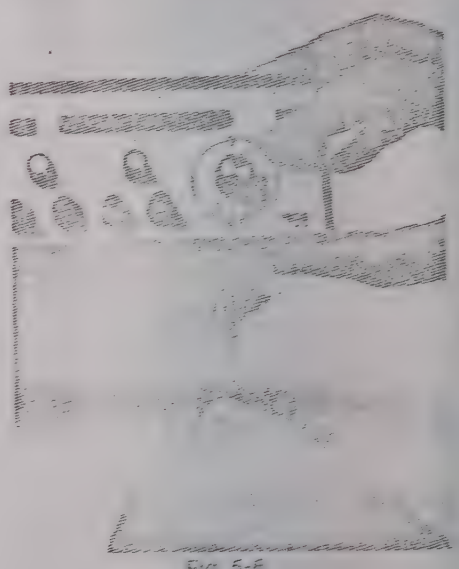


Fig. 5-6

Alignment of Multiplier Knob

SECTION 6

SCHEMATICS

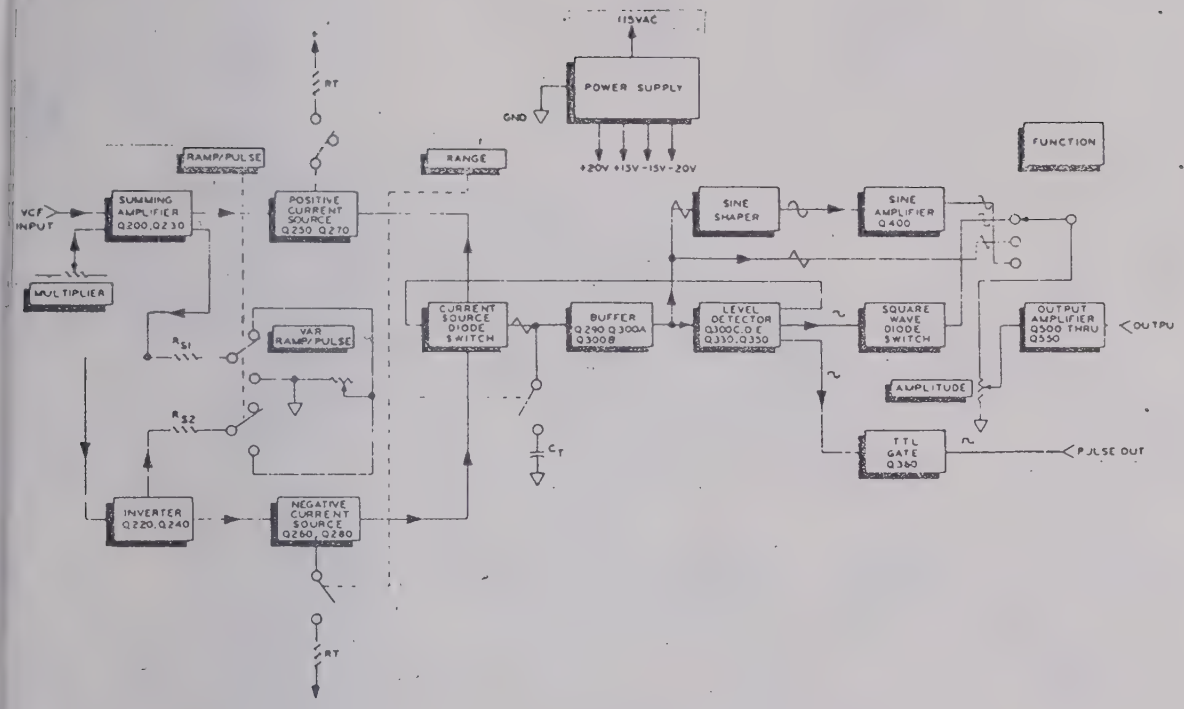
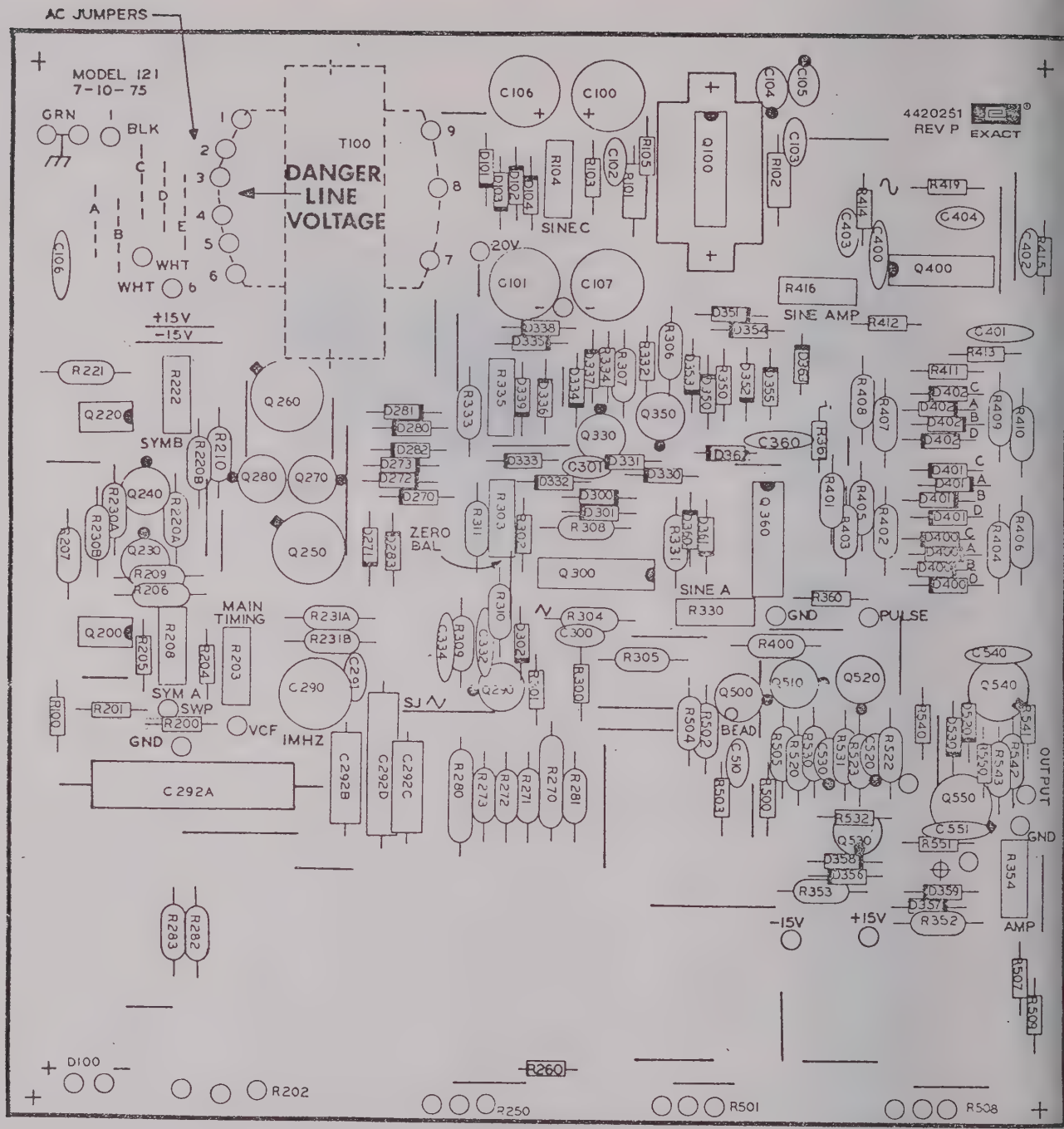
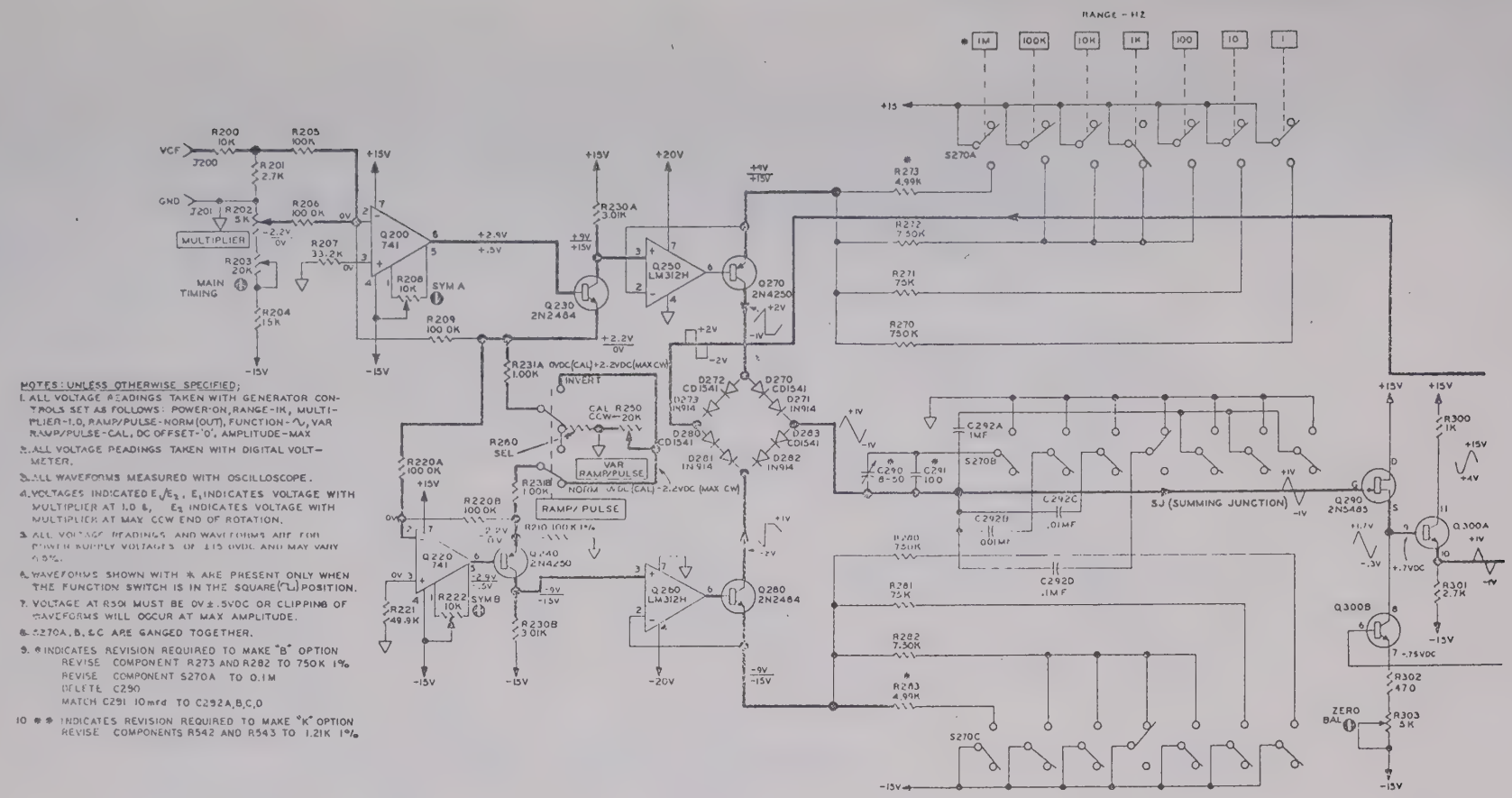


Fig. 6-1 Block Diagram

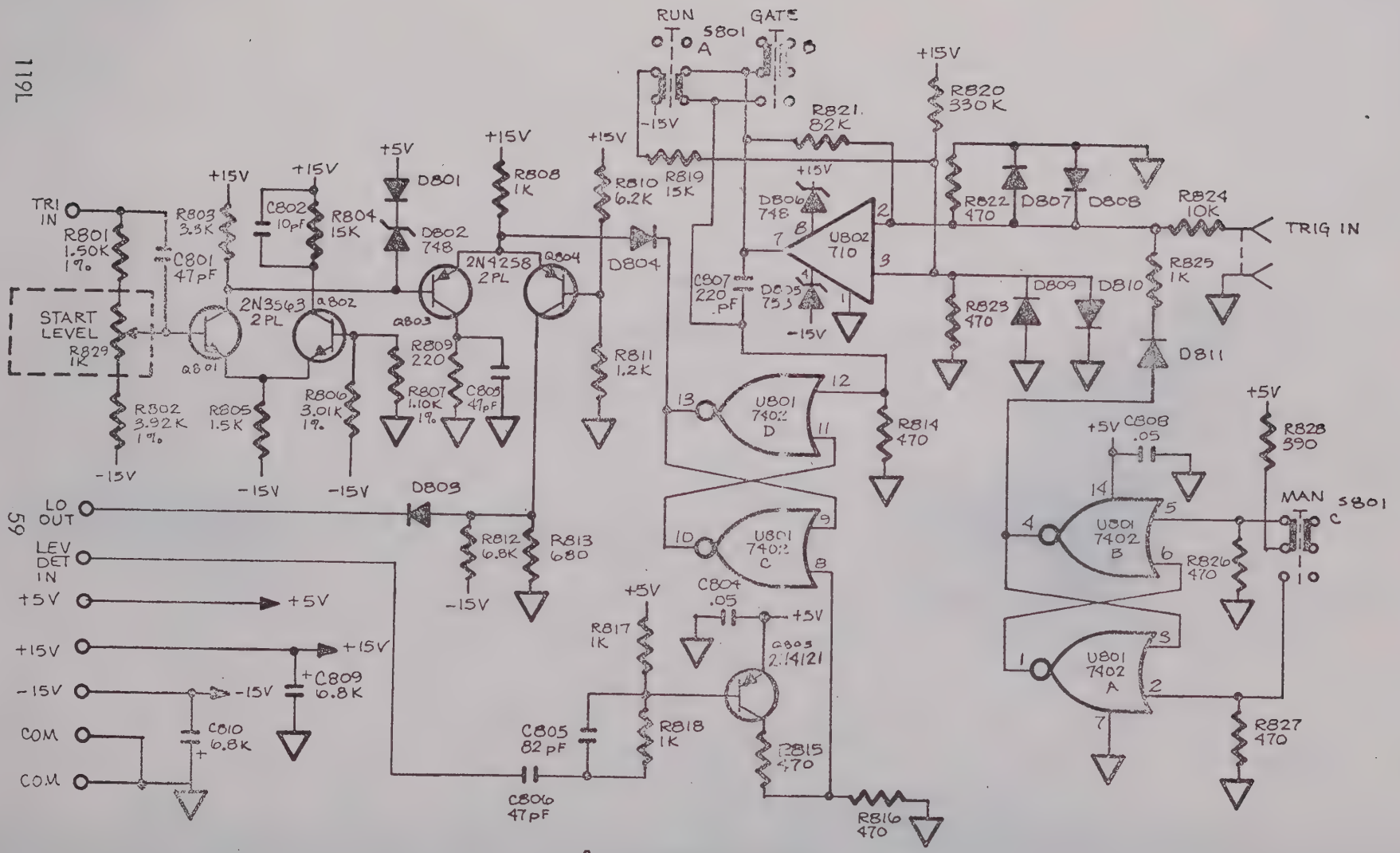

AC JUMPERS
MODEL 121
7-10-75
GRN
BLK
WHT
WHT
T100
DANGER
LINE
VOLTAGE
SINE C
20V
+15V
-15V
SYMB
SYM A
SWP
VCF
GND
MAIN
TIMING
IMHZ
ZERO
BAL
SJ
SINE A
SINE AMP
BEAD
PULSE
OUTPUT
AMP
4420251
REV P
EXACT
C106
C100
C104
C105
C103
Q100
R102
R104
R105
C102
R101
R103
D101
D102
D103
D104
R419
C404
C403
C414
C400
Q400
C402
R415
R416
R412
D351
D354
C401
R415
R411
D402
D403
D404
D405
R408
R407
R409
R410
D401
D406
R404
R401
R405
R403
R402
C360
R361
D362
Q360
R360
GND
R330
D360
R331
D361
Q300
R300
R304
C300
R305
R400
Q500
Q510
Q520
Q540
R504
R502
R505
R510
R520
C530
R531
R523
C520
R522
R540
C540
R541
R542
R543
C550
C551
R551
R532
Q530
D358
D356
R353
D359
D357
R352
R354
-15V
+15V
R507
R508
R501
R260
R250
R202
D100
Q260
Q280
Q270
Q250
Q220
R221
R222
R220B
R210
R230A
R230B
R220A
Q240
Q230
R207
R209
R206
Q200
R208
R205
R204
R203
R201
R200
R100
R231A
R231B
C291
C290
C292A
C292B
C292D
C292C
R283
R282
Q350
Q330
C301
D330
D331
D332
D333
R333
R335
D339
D336
D334
D337
R307
R332
R306
D353
D350
D352
D355
D281
D280
D282
D273
D272
D270
D271
D283
R303
R311
R302
R308
D300
D301
R310
R309
C334
C332
D302
D301
R300
Q300
R280
R273
R272
R271
R270
R281



NOTES: UNLESS OTHERWISE SPECIFIED;

1. ALL VOLTAGE READINGS TAKEN WITH GENERATOR CONTROLS SET AS FOLLOWS: POWER-ON, RANGE-1K, MULTIPLIER-1.0, RAMP/PULSE-NORM (OUT), FUNCTION-∿, VAR RAMP/PULSE-CAL, DC OFFSET-'0', AMPLITUDE-MAX
2. ALL VOLTAGE READINGS TAKEN WITH DIGITAL VOLTMETER.
3. ALL WAVEFORMS MEASURED WITH OSCILLOSCOPE.
4. VOLTAGES INDICATED E_1/E_2, E_1 INDICATES VOLTAGE WITH MULTIPLIER AT 1.0 &, E_2 INDICATES VOLTAGE WITH MULTIPLIER AT MAX CCW END OF ROTATION.
5. ALL VOLTAGE READINGS AND WAVEFORMS ARE FOR POWER SUPPLY VOLTAGES OF ±15 VDC AND MAY VARY 5%.
6. WAVEFORMS SHOWN WITH * ARE PRESENT ONLY WHEN THE FUNCTION SWITCH IS IN THE SQUARE (⊓⊔) POSITION.
7. VOLTAGE AT R301 MUST BE 0V ± .5VDC OR CLIPPING OF WAVEFORMS WILL OCCUR AT MAX AMPLITUDE.
8. S270A, B, & C ARE GANGED TOGETHER.
9. * INDICATES REVISION REQUIRED TO MAKE "B" OPTION
   REVISE COMPONENT R273 AND R282 TO 750K 1%
   REVISE COMPONENT S270A TO 0.1M
   DELETE C290
   MATCH C291 10mfd TO C292A,B,C,D
10. ** INDICATES REVISION REQUIRED TO MAKE "K" OPTION
    REVISE COMPONENTS R542 AND R543 TO 1.21K 1%

7000457 REV J

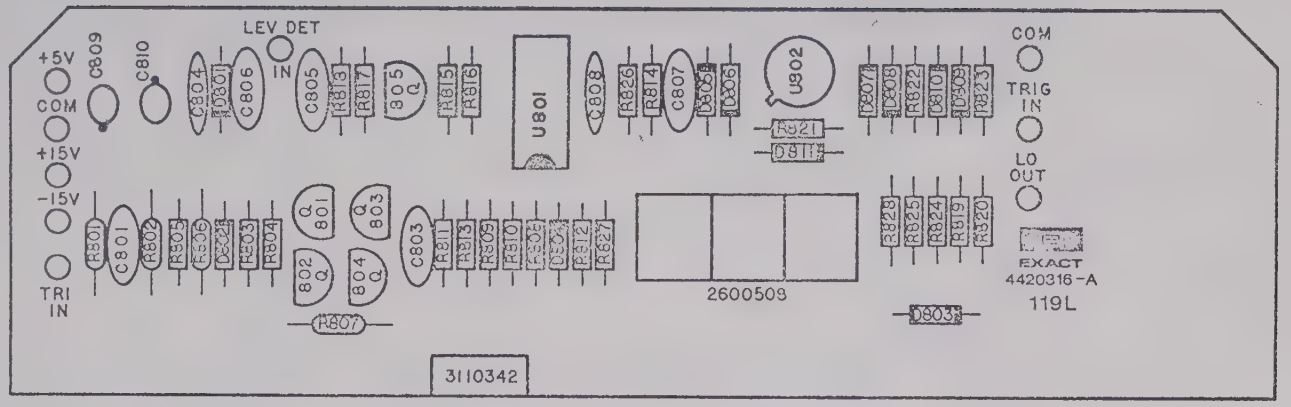


2. LAST REF DES USED:
a) U802
b) R829
c) D811
d) C810
e) Q805

1. ALL DIODES 1N914

NOTES: UNLESS OTHERWISE SPECIFIED

MODEL 119L
LOCKOUT
7000651


+5V
COM
+15V
-15V
TRI IN
C809
C810
LEV DET IN
C804
D801
C806
C805
R813
R817
Q 805
R815
R816
U801
C808
R826
R814
C807
D805
D806
U802
R821
D811
D807
D808
R822
R810
D809
R823
COM
TRIG IN
LO OUT
R801
C801
R802
R803
D802
R805
R803
R804
Q 801
Q 802
Q 803
Q 804
R807
C803
R811
R813
R809
R810
D803
D804
R812
R827
2600509
R828
R825
R824
R819
R320
D803
EXACT
4420316-A
119L
3110342

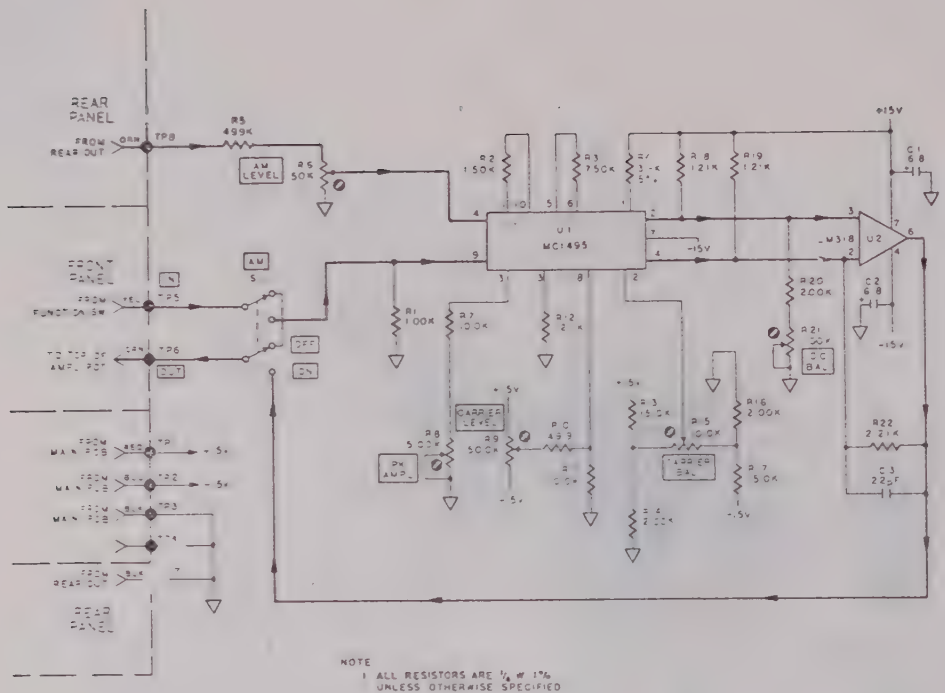
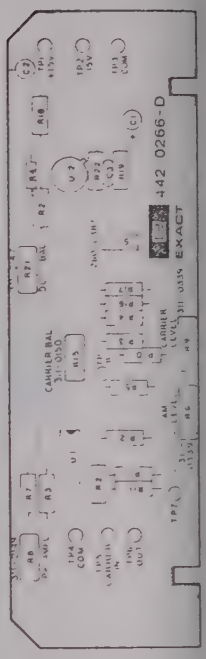
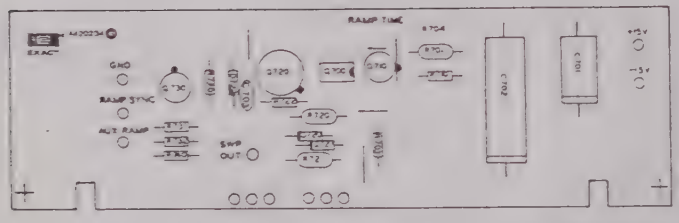


Fig. 6-5



MODEL 119M
AM PCB
7000512 REV B



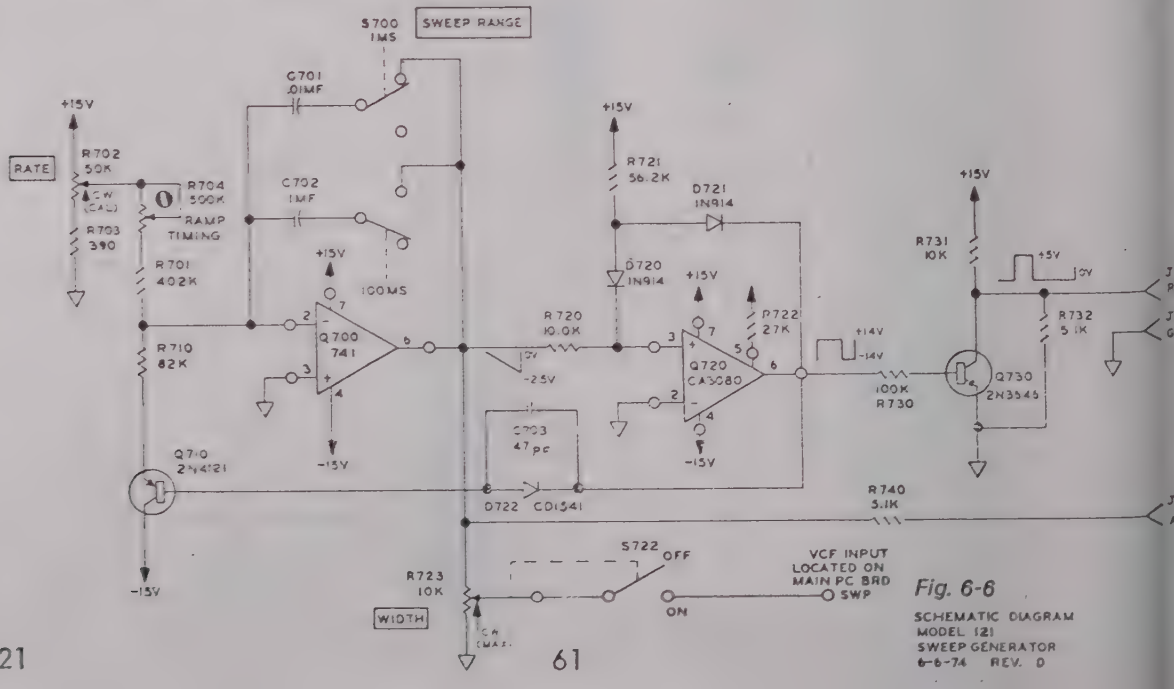


Fig. 6-6

SCHEMATIC DIAGRAM
MODEL 121
SWEEP GENERATOR
6-6-74 REV. D

SECTION 7

PARTS LIST

CODE LIST OF MANUFACTURERS

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidsell Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Prod. Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Eng. Labs, Inc	Burlington, Wis.
00853	Sangamo Electric Co. Ordill Div. (Cups)	Marion, Illinois
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Prod. Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Inc.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Illinois
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp/Amer.	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg El. Corp.	Chicago, Illinois
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Company of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E., Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine and Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04013	Taunus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q, Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co. Electronics Div.	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Illinois
04404	Oymac Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prod., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola/Semicon. Prod.	Phoenix, Ariz.ona
04732	Filmax Co/Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Illinois
04777	Automatic Elect. Sales Corp.	Northlake, Illinois
04796	Sequoia Wire/Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Co.	Chicago, Illinois
05006	20th Century Plastics	Los Angeles, Calif.
05277	Westinghouse/Semicon. Dept.	Youngwood, Pa.
05547	Utronix, Inc.	San Mateo, Calif.
05593	Illumitronic Eng. Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Illinois
05728	Tiffen Optical Co.	Roslyn Heights, L.I., N.Y.
05729	Metropolitan Telecomm. Corp Metro Cap Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical	Rochester, N.Y.
06402	E.T.A. Products/Amer.	Chicago, Illinois
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Elect. Hardware Co.	New Rochelle, N.Y.
06555	Beede Electrical Inst.Co.	Penacook, N.H.
06751	U.S. Semicon Div. of Nuclear Corp/Amer.	Phoenix, Ariz.
06812	Torrington Mfg Co, West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronics Comp. Dept.	Bradford, Pa.
07126	Dgitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Bircher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Labs	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Elkon, Division, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario
08717	Sloan Company	Burbank, Calif.
08718	Cannon Elect Co, Phoenix Div.	Phoenix, Ariz.
08792	CBS Elect. Semiconductor Oper., Div. C.B.S., Inc.	Lowell, Mass.
08984	Mel-Ram	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atahm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc	Chicago, Illinois
09569	Mallory Battery Co/Canada Ltd	Toronto, Ontario, Canada
09664	The Bristol Company	Waterbury, Conn.
10714	Gen. Trans. Western Corp.	Los Angeles, Calif
10911	Ti-Tal, Inc.	Berkeley, Calif.
10947	Exact Electronics, Inc.	Hillsboro, Oreg.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Tel. of Calif., Inc.	S. Pasadena, Calif.
11312	Microwave Elect. Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	Gen'l Inst-Semiconductor Div	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12040	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12854	Nippon Elect. Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13050	Thermalloy	Dallas, Texas
13296	Telefunken (G.M.B.H.)	Hannover, Germany
13655	Midland Mfg. Co.	Kansas City, Kansas
14040	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components Inc.	Conshohocken, Pa.
14433	Cornell Dubilier El. Corp.	So. Plainfield, N.J.
14662	Williams Mfg. Co.	San Jose, Calif.
15023	Webster Elect., Co., Inc.	Brooklyn, N.Y.
15090	Adjustable Bushing Co.	N. Hollywood, Calif.
15174	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16125	Computer Diode Corp.	Lodi, N.J.
16258	De Jur-Amsco Corp.	Long Island City, N.Y.
16758	Delco Radio, Division of G.M. Corp.	Kokomo, Ind.
17474	Thermometrics, Inc.	Canoga Park, Calif.
17545	Trones Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Illinois
18511	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18677	E.I. Dupont and Co., Inc.	Wilmington, Del.
19013	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thermoelectric Co. Div. McGraw-Edison Co.	West Orange, N.J.
1979	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Illinois
21835	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24655	General Radio Co.	W. Concord, Mass.
26361	Grist Reproducer Corp.	New Rochelle, N.Y.
26460	Grobet File Co/America, Inc.	Carlstadt, N.J.
26990	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	GE Receiving Tube Dept.	Owensboro, Ky.
33432	Lectrohm, Inc.	Chicago, Ill.
36 9e	Stanwyck Corp.	Hawkesburn, Ontario, Cd.
37042	P.R. Mallory and Co., Inc.	Indianapolis, Ind.
38642	Mechanical Industries Prod.	Akron, Ohio
40920	Miniature Precision Bearings	Keene, N.H.
42 9C	Muter Co.	Chicago, Illinois
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Illinois
47904	Palaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer/Inst.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
52744	Ward Leonard Electric	Mt. Vernon, N.Y.
52853	Chalicross Mfg. Co.	Selma, N.C.
53009	Simpson Electric Co.	Chicago, Illinois
53021	Sonotone Co.	Elmyford, N.Y.
53569	Sorenson and Co., Inc.	S. Norwalk, Conn.
53650	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
53711	Sprague Electric Co.	N. Adams, Mass.
53780	Talex, Inc.	St. Paul, Minn.
53942	Thomas and Betts Co.	Elizabeth, N.J.
54294	Tripplett Electrical Inc.	Bluffton, Ohio
54583	Union Switch and Signal, Div. Westinghouse Air Brake Co.	Swissvale, Pa.
54738	Universal Electric Co.	Ososo, Mich.
54839	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
54915	Western Electric Co., Inc.	New York, N.Y.
55026	West Inst./Div. Daystrom	Newark, N.J.
55183	Wittek Manufacturing Co.	Chicago, Illinois
55340	Wollensak Optical Co.	Rochester, N.Y.
55566	Allen Manufacturing Co.	Hartford, Conn.
55821	Allied Control Co., Inc.	New York, N.Y.
55910	Allmetal Screw Prod. Co, Inc.	Garden City, N.Y.
56022	Atlantic Indio Rubber Works	Chicago, Illinois
56200	Amperite Co., Inc.	New York, N.Y.
56289	Belden Manufacturing Co.	Chicago, Illinois
56483	Bird Electronic Corp.	Cleveland, Ohio
56699	Birnbach Radio Co.	New York, N.Y.
56845	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
56878	Bud Radio Inc.	Cleveland, Ohio
56915	Cambridge Thermionic Corp.	Cambridge, Mass.
56929	Centralab, Div. Globe Union, Inc.	Milwaukee, Wis.
56942	Commercial Plastics Co.	Chicago, Illinois
56981	The Cornish Wire Co.	New York, N.Y.
57033	Chicago Miniature Lamp Wks	Chicago, Illinois
57065	A. O. Smith Corp. Crowley Div.	West Orange, N.J.
57124	Cinch Mfg. Corp.	Chicago, Illinois
57294	Dow Corning Corp.	Midland, Mich.
57295	Ferri-McCullough, Inc.	San Bruno, Calif.
57330	Electro Motive Mfg. Co, Inc.	Willimantic, Conn.
57363	Cera Call, Co., Inc.	Providence, R.I.
57364	John E Fast and Company	Chicago, Illinois
57373	Dialight Corp.	Brooklyn, N.Y.
57396	General Ceramics Corp.	Keasbey, N.J.
57417	General Instrument Corp. Semiconductor Div.	Newark, N.J.
57455	Girard-Hopkins	Oakland, Calif.
57473	Drake Mfg. Co.	Chicago, Illinois
57520	Hugh H. Eby, Inc.	Philadelphia, Pa.
57530	Gudeman Co.	Chicago, Illinois
57533	Robert M. Hadley Co.	Los Angeles, Calif.
57545	Erie Resistor Corp.	Erie, Pa.
57583	Hansen Mfg. Co., Inc.	Princeton, Ind.
57605	H. M. Harper Co.	Chicago, Illinois
57638	Heliopot. Div. Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. No. American Phillips Co., Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	S. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73637	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Illinois
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping and Tool	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite, Inc.	Neptune, N.J.
74455	J. H. Winns and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Illinois
74868	R.F. Prod. Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	James, Howard B., Div. of Cinch Mfg. Corp.	Chicago, Illinois
75375	James Knights Co.	Sandwich, Illinois
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75818	Lena Electric Mfg. Co.	Chicago, Illinois
75915	Littelfuse, Inc.	Des Plaines, Illinois
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	Monadnock Mills	San Leandro, Calif.
76530	Mueller Electric Co.	Cleveland, Ohio
76545	Oak Manufacturing Co.	Crystal Lake, Illinois
76854	Bendix Pacific Div. of Bendix Corp.	N. Hollywood, Calif.
77068	Pacific Metals Co.	San Francisco, Calif.
77071	Phaostron Instrument and Electronic Co.	S. Pasadena, Calif.
77221	Phosti Manufacturing Co.	Chicago, Illinois
77250	Philadelphia Steel and Wire Corporation	Philadelphia, Pa.
77252	Potter and Brumfield, Div. of American Machine/Foundry	Princeton, Ind.
77342	Radio Condenser Co.	Camden, N.J.
77630	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77638	Resistance Products Co.	Harrisburg, Pa.
77764	Rubbercraft Corp. of Calif.	Torrance, Calif.
77969	Shakeproof, Div. of Illinois Tool Works	Elgin, Illinois
78189	Signal Indicator Corp.	New York, N.Y.
78283	Struthers-Dunn, Inc.	Pitman, N.J.
78290	Thomas Industrial Co.	Chicago, Illinois
78452	Tilley Manufacturing Co.	San Francisco, Calif.
78471	Stackpole Carbon Co.	St. Marys, Pa.
78488	Standard Thomson Corp.	Waltham, Mass.
78493	Tinnerman Products, Inc.	Cleveland, Ohio
78553	Transformer Engineers	Pasadena, Calif.
78790	Ucinite Co.	Newtonville, Mass.
78947	Veeder Root, Inc.	Hartford, Conn
79042	Wenco Mfg. Co.	Chicago, Illinois
79121	Continental-Wirt Elect. Corp.	Philadelphia, Pa
79727	Zierick Mfg. Corp.	New Rochelle, N.Y.
79963	Mepco, Div. of Sessions Clock Company	Morristown, N.J.
80031	Schnitzer Alloy Products	Elizabeth, N.J.
80120	Times Facsimile Corp.	New York, N.Y.
80130	Electronic Industries Assoc. Any brand tube meeting EIA standards.	Washington D.C.
80131	Unimax Switch, Div. of W L Maxson Corp.	Wallingford, Conn.
80207	Union Transformer Corp.	New York, N.Y.
80222	Oxford Electric Corp.	Chicago, Illinois
80248	Bourns Laboratories, Inc.	Riverside, Calif
80294	Acro, Div. Robershaw Fulton Controls Co.	Columbus, Ohio
80411	All Star Products, Inc.	Columbus, Ohio
80486	Avery Adhesive Label Corp.	Defiance, Ohio
80509	Hammarlund Co., Inc.	Monrovia, Calif.
80583	Stevens, Arnold Co., Inc.	New York, N.Y.
80640	International Instruments, Inc.	Boston, Mass.
81030	Groyhill Co.	New Haven, Conn.
81073	Triad Transformer Corp.	LaGrange, Illinois
81095	Switchcraft, Inc.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81349	Military Specifications	Washington D.C.
81415	Wilbor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div, Industrial Tube Oper.	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass
81860	Barry Controls, Inc.	Watertown, Mass
82042	Carter Parts Co.	Skokie, Illinois
82142	Jeffers Electronics, Div. of Speer Carbon Co.	DuBois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod., Electronic Tube Div.	Emporium, Pa.
82376	Astron Company	E. Newark, N.J.
82389	Switchcraft, Inc.	Orange, Illinois
82647	Metals and Controls, Inc., Div. Texas Instruments, Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wisc.
82877	Ratran Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, California
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83149	Electra Corn Co.	Los Angeles, Calif
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp/Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Marde gin, Illinois
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Illinois
83501	Gavitt Wire and Cable Co., Div. Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Co.	Boonton, N.J.
85474	R.M. Bracmonte and Co.	San Francisco, Calif.
85660	Koiled Kards, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Illinois
86197	Clifton Precision Products	Clifton Heights, Pa
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansing Div.)	Lansing, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco
87864	Van Waters and Rogers, Inc.	Seattle, Wash.
87930	Tomer Mfg. Co.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Illinois
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89731	Greyhar Electric Co.	Garland, Calif.
89462	Weldes Kohlmeyer, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baker Co.	Chicago, Illinois
89665	United Transformer Co.	Chicago, Illinois
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Illinois
91506	Augor Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia
91737	Gremar Mfg Co., Inc.	Wakefield, Mass.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Illinois
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod, Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc	Mansfield, Ohio
93788	Howard J. Smith, Inc.	Port Monmouth, N.J.
93929	G.V. Controls	Livingston, N.J.
93983	Imuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Comp. Div, Rec. Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div, Calif. St. Plt	Newton, Mass.
94148	Scientific Products	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	E. Paterson, N.J.
94222	Southco, Div. S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod., Model Engineering and Mfg. Co.	Chicago, Illinois
94330	Wire Cloth Products, Inc.	Chicago, Illinois
94682	Worcester Pressed Alum. Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allied Products Corp.	Miami, Fla.
95238	Continental Screw Corp.	Woonsida, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lorco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Cambe Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Illinois
95712	Doge Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Illinois
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Ni-Q Div. of Aerovox	Olean, N.Y.
96256	Thorarson-Meissner, Div. Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Illinois
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J
97539	Automatic and Precision Mfg.	Yonkers, N.Y.
97966	CBS Electronics Div. C.B.S., Inc.	Danvers, Mass.
97979	Rean Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers, Inc.	Jamaica, N.Y.
98159	Rubber Tech, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	S. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Coral Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Div. Controls Co. of America	El Segundo, Calif
99800	Delevan Electronics Corp.	E. Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Illinois
99957	Technology Instrument Corp. of California	Newbury Park, Calif.

1	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
2	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
3	CAPACITOR, 22PF	2810530	853
0	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
1	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
2	CAPACITOR, 1000 PF DISC	2830000	91418
3	CAPACITOR, 1000 PF DISC	2830000	91418
4	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
5	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
6	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
7	CAPACITOR, 250 MFD 25 VOLT	2900058	10597
0	CAPACITOR, 8-50PF TRIM	2810022	72982
1	CAPACITOR, 100PF MICA	2810537	853
2	CAPACITOR, TIMING SET	2950010	10597
0	CAPACITOR, 47PF MICA	2810532	853
1	CAPACITOR, 12PF MICA	2810541	853
2	CAPACITOR, 0.05 UF DISCAP	2830010	91418
4	CAPACITOR, 0.05 UF DISCAP	2830010	91418
0	CAPACITOR, 0.01 UF DISCAP	2830005	91418
0	CAPACITOR, 0.01 UF DISCAP	2830005	91418
1	CAPACITOR, 0.01 UF DISCAP	2830005	91418
2	CAPACITOR, 39PF MICA	2810531	853
3	CAPACITOR, 39PF MICA	2810531	853
4	CAPACITOR, 5PF MICA	2810501	853
0	CAPACITOR, 2PF MICA	2810542	10597
0	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
0	CAPACITOR, 6.8 MFD 35 VOLT	2900043	100002
0	CAPACITOR, 0.05 UF DISCAP	2830010	91418
0	CAPACITOR, 0.05 UF DISCAP	2830010	91418
1	CAPACITOR, 0.05 UF DISCAP	2830010	91418
1	CAPACITOR, 0.01 MFD 600V	2900019	37942
2	CAPACITOR, 1MF 100V	2900065	10597
3	CAPACITOR, 47PF MICA	2810532	853
0	LED, MLED650	1520002	4713
1	DIODE, 1N4001	1524001	1295
2	DIODE, 1N4001	1524001	1295
3	DIODE, 1N4001	1524001	1295
4	DIODE, 1N4001	1524001	1295
0	DIODE, FDH 333	1520333	1295
1	DIODE, 1N914	1520914	7910
2	DIODE, FDH 333	1520333	1295
3	DIODE, 1N914	1520914	7910
0	DIODE, FDH333	1520333	1295
1	DIODE,1N914	1520914	7910
2	DIODE, 1N914	1520914	7910
3	DIODE, FDH333	1520333	1295
0	DIODE, 1N914	1520914	7910
1	DIODE, 1N914	1520914	7910
2	DIODE, 1N914	1520914	7910
0	DIODE, 1N914	1520914	7910
1	DIODE, 1N914	1520914	7910
2	DIODE, 1N914	1520914	7910
3	DIODE, 1N914	1520914	7910
4	DIODE, 1N914	1520914	7910
5	DIODE, 1N914	1520914	7910
6	DIODE, 1N914	1520914	7910
7	DIODE, 1N914	1520914	7910
8	DIODE, 1N914	1520914	7910
9

R280	RESISTOR, 750K OHM 1/4W 1% METAL FILM	3137503	7115
R281	RESISTOR, 75K OHM 1/4W 1% METAL FILM	3137502	7115
R282	RESISTOR, 7500 OHM 1/4 1% METAL FILM	3137501	7115
R283	RESISTOR, 4990 OHM 1/4W 1% METAL FILM	3134991	7115
R283	RESISTOR, 750K OHM 1/4W 1% METAL FILM	3137503	7115
R300	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R301	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R302	RESISTOR, 470 OHM 1/4W 5% CARBON	3070471	7115
R303	POTENTIOMETER, 10K OHM TRIM	3110150	71450
R304	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R305	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R306	RESISTOR, 4020 OHM 1/4W 1% METAL FILM	3134021	7115
R307	RESISTOR, 4020 OHM 1/4W 1% METAL FILM	3134021	7115
R308	RESISTOR, 499 OHM 1/4W 1% METAL FILM	3134990	7115
R309	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R310	RESISTOR, 30100 OHM 1/4W 1% METAL FILM	3133012	7115
R311	RESISTOR, 2000 OHM 1/4W 1% METAL FILM	3132001	7115
R330	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R331	RESISTOR, 13000 OHM 1/4 1% METAL FILM	3131302	7115
R332	RESISTOR, 910 OHM 1/4W 5% CARBON	3070911	1121
R333	RESISTOR, 13000 OHM 1/4W 1% METAL FILM	3131302	7115
R334	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R335	POTENTIOMETER, 2K OHM PC TRIM	3110130	78488
R350	RESISTOR, 2700 OHM 1/4W 5% CARBON	3070272	1121
R352	RESISTOR, 12.1K OHM 1/4W 1% METAL FILM	3131212	7115
R353	RESISTOR, 12.1K OHM 1/4W 1% METAL FILM	3131212	7115
R354	POTENTIOMETER, 1K OHM TRIM	3110147	71450
R360	RESISTOR, 10 OHM 1/4W 5% CARBON	3070100	1121
R361	RESISTOR, 7500 OHM 1/4W 5% CARBON	3070752	1121
R400	RESISTOR, 49.9 OHM 1/4W 1% METAL FILM	3130499	7115
R401	RESISTOR, 11300 OHM 1/4W 1% METAL FILM	3131132	7115
R402	RESISTOR, 11300 OHM 1/4W 1% METAL FILM	3131132	7115
R403	RESISTOR, 12100 OHM 1/4W 1% METAL FILM	3131212	7115
R404	RESISTOR, 309 OHM 1/4W 1% METAL FILM	3133090	7115
R405	RESISTOR, 12100 OHM 1/4W 1% METAL FILM	3131212	7115
R406	RESISTOR, 200 OHM 1/4W 1% METAL FILM	3132000	7115
R407	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R408	RESISTOR, 24900 OHM 1/4W 1% METAL FILM	3132492	7115
R409	RESISTOR, 127 OHM 1/4W 1% METAL FILM	3131270	7115
R410	RESISTOR, 63.4 OHM 1/4W 1% METAL FILM	3130634	7115
R411	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R412	RESISTOR, 5100 OHM 1/4 5% CARBON	3070512	1121
R413	RESISTOR, 1000 OHM 1/4 5% CARBON	3070102	1121
R414	RESISTOR, 150 OHM 1/4W 5% CARBON	3070151	1121
R415	RESISTOR, 680 OHM 1/4W 5% CARBON	3070681	1121
R416	POTENTIOMETER, 1K OHM PC TRIM	3110147	78488
R419	RESISTOR, 6800 OHM 1/4W 5% CARBON	3070682	1121
R500	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R501	POTENTIOMETER, 50K	3110339	10597
R502	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R503	RESISTOR, 8200 OHM 1/4W 5% CARBON	3070822	1121
R504	RESISTOR, 1000 OHM 1/4W 1% METAL FILM	3131001	7115
R505	RESISTOR, 9090 OHM 1/4W 1% METAL FILM	3139091	7115
R507	RESISTOR, 1000 OHM 1/4W 5% CARBON	3070102	1121
R508	POTENTIOMETER, 1K	3110342	10597
R509	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R520	RESISTOR, 174 OHM 1/4W 1% METAL	3131740	7115
R521	RESISTOR, SELECTED VALUE		
R522	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R523	RESISTOR, 24300 OHM 1/4W 1% METAL FILM	3132432	7115
R530	RESISTOR, 274 OHM 1/4W 1% METAL FILM	3132740	7115
R531	RESISTOR, 3010 OHM 1/4W 1% METAL FILM	3133011	7115
R532	RESISTOR, 100 OHM 1/4W 5% CARBON	3070101	1121
R540	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R541	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R542	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R542	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R543	RESISTOR, 100 OHM 1/4W 1% METAL FILM	3131000	7115
R543	RESISTOR, 1210 OHM 1/4W 1% METAL FILM	3131211	7115
R544	RESISTOR, 453 OHM 1/2W 1% METAL FILM	3104530	7115
R545	RESISTOR, 56.2 OHM 1/4W 1% METAL FILM	3130562	7115
R546	RESISTOR, 41.2 OHM 1/2W 1% METAL FILM	3100412	7115
R547	RESISTOR, 41.2 OHM 1/2W 1% METAL FILM	3100412	7115
R548	RESISTOR, 10.0 OHM 1/4W 1% METAL FILM	3130100	7115
R550	RESISTOR, 15 OHM 1/4W 5% CARBON	3070150	1121
R551	RESISTOR, 47 OHM 1/4W 5% CARBON	3070470	1121
R552	RESISTOR, 1580 OHM 1/4W 1% METAL FILM	3131581	1121
R553	RESISTOR, 510 OHM 1/4W 1% METAL FILM	3130511	1121
R701	RESISTOR, 402K OHM 1/4W 1% METAL FILM	3134023	7115
R702	POTENTIOMETER, 50K	3110339	10597
R703	RESISTOR, 560 OHM 1/4W 5% CARBON	3070561	1121
R704	POTENTIOMETER, 500K OHM PC TRIM	3110132	78488
R710	RESISTOR, 82K OHM 1/4W 5% CARBON	3070823	1121
R720	RESISTOR, 10000 OHM 1/4W 1% METAL FILM	3131002	7115
R721	RESISTOR, 56200 OHM 1/4W 1% METAL FILM	3135622	7115
R722	RESISTOR, 27K OHM 1/4W 5% CARBON	3070273	1121
R723	POTENTIOMETER, 10K OHM WITH SWITCH	3110343	10
R730	RESISTOR, 100K OHM 1/4W 5% CARBON	3070104	11
R731	RESISTOR, 10K OHM 1/4W 5% CARBON	3070103	11
R732	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	11
R740	RESISTOR, 5100 OHM 1/4W 5% CARBON	3070512	11
S001	SWITCH, CTS 206-122 DIP	2600431	10
S100	SWITCH, PUSHBUTTON DPDT	2600375	10
S270	SWITCH, PUSHBUTTON 13 STATION	2600376	10
S501	SWITCH, MIN. ROTARY 3P3T	2600090	76
S700	SWITCH, 2 STATION INTERLOCK	2600378	71
T100	TRANSFORMER, POWER	1200058	10
U001	INTEGRATED CIRCUIT, MC1495L	1581495	47
U002	INTEGRATED CIRCUIT, LM318	1580318	47

SECTION 8

ADDENDA